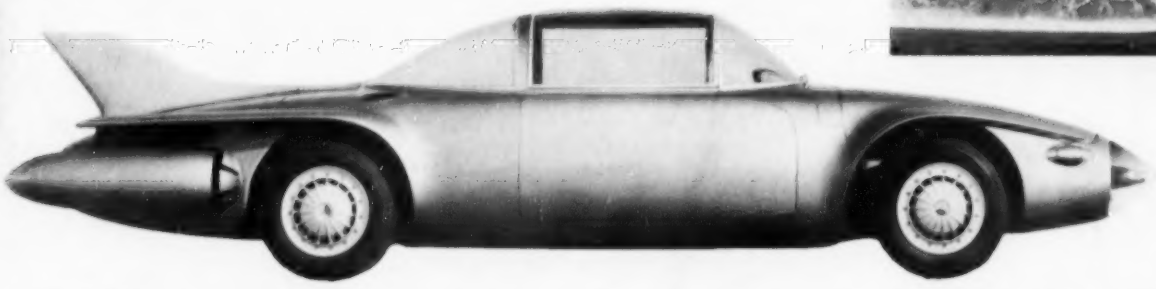
IN THIS ISSUE:

Civil Defense In the Missile Age



What Happened to the Gas Turbine?

Perfection at Low Temperatures

engineer

APRIL, 1958
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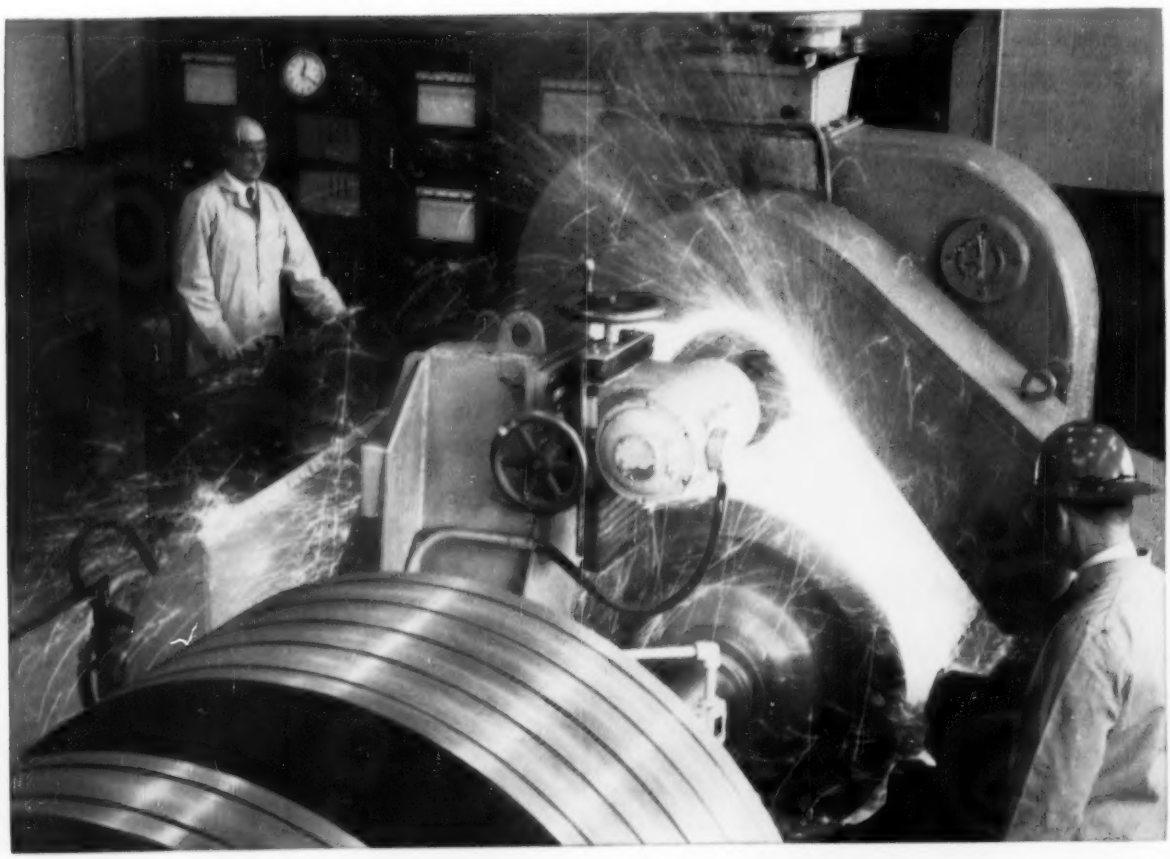

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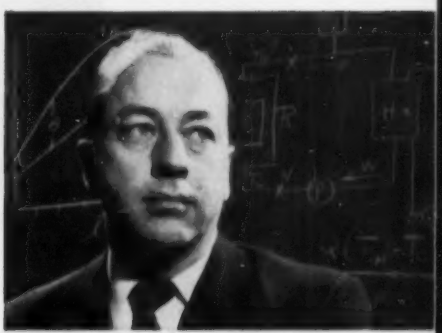
AIMS TORPEDOES. C. H. Jones (Northwestern—EE) is Assistant Department Manager of electronics and nuclear physics department. He recently invented a new device for underwater acoustics applications. While at Westinghouse he has supervised varied research projects on color TV, antennas, micro waves, radar and sonar.

BATTLEFIELD RADAR. J. W. Currie (U. S. Naval Academy—EE) and C. J. Miller (Virginia Polytech—EE) check fabric of the huge Westinghouse paraballoon, which they developed with the help of Cornell Aeronautical Laboratories. This lollypop-shaped device, more than 30 feet high when inflated, makes possible for the first time a lightweight, mobile radar antenna which can be set up near the front lines to support ground troops in battle.



ATOMIC FLEET ENGINEER. P. N. Ross (Harvard —EE) is assistant manager of Large Ship Reactor Project for Westinghouse. He joined the company as a graduate student, rose rapidly in nuclear work. Mr. Ross played a key role in development of USS Nautilus, the first atomic submarine.

HEADED NEMA. J. H. Jewell (Pratt Institute—ME) headed National Electrical Manufacturers Association in 1954-55. He is Westinghouse vice president in charge of marketing.

TURBINE EXPERT. C. C. Franck Sr. (Johns Hopkins—MME) is consulting engineer in Westinghouse Steam Division. His research helped develop the Normandy invasion fleet. He is an internationally-known authority on steam turbines.

UTILITY "DOCTOR." As head of the Westinghouse Electric Utility Engineering Section, J. K. Dillard (Georgia Tech.—EE) helps diagnose ills and treat problems of 220 electric utilities across the nation. AC calculating board in background is largest computer of its kind in industry.

AIEE PRESIDENT. A. C. Monteith (Queen's University, Kingston, Ontario) was 1954-55 president of AIEE. He is vice president in charge of all Westinghouse apparatus products divisions.

WINS LAMME MEDAL OF AIEE. The Lamme Medal, one of the nation's top honors in electrical engineering, was won in 1955 by Dr. Clinton R. Hanna, (Purdue—EE) associate director of Westinghouse Research Laboratories. Left to right: Dr. John A. Hutcheson, (North Dakota—EE), Westinghouse vice president in charge of engineering; Dr. Hanna; and M. D. Hooven, AIEE head. Seven other Westinghouse engineers have won the Lamme Medal and 11 others the AIEE's Edison Medal.

MOST EFFICIENT POWER STATION. J. W. Batchelor (Purdue—EE), head of Westinghouse Turbine Generator Engineering Dept., looks over the equipment which he helped to develop at Kyger Creek (Ohio) power station. The Federal Power Commission labelled this the most efficient station in the nation for 1955. Four Westinghouse turbine generators, each rated at 217,260 kilowatts, are there.

MODERN-DAY PIONEER. Dr. R. A. Ramey, Jr. (U. of Cincinnati—EE), is a pioneer in magnetic amplifiers. Joining Westinghouse in 1952 as a section engineering manager, he is now manager, new products department. He also had an important part in guiding the development of Cypak, the Westinghouse industrial control unit that thinks, decides and remembers.

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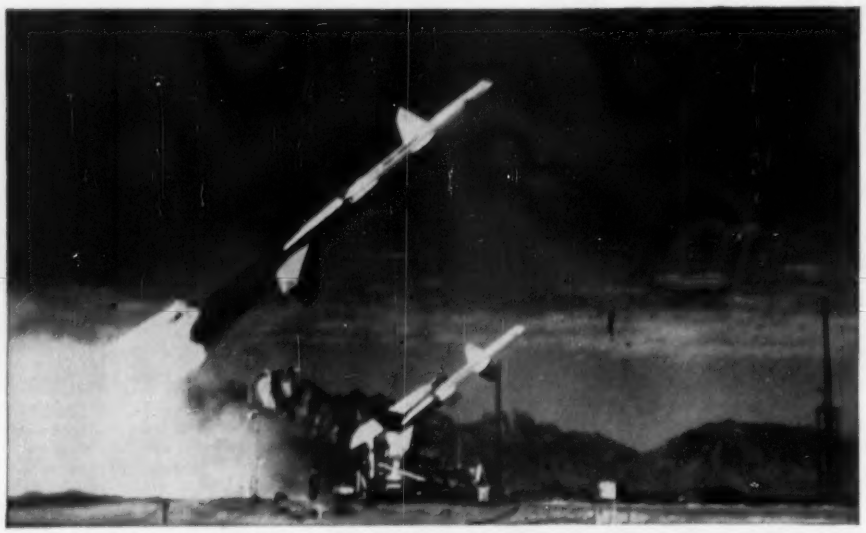

First uncensored photo of TALOS, long range guided missile developed by APL for the Navy.

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Today two guided missiles that grew out of our pioneer work are in production: the TERRIER is now a fleet service weapon, and TALOS (above) has been adapted for land as well as ship-based operation. When TALOS was recently unveiled by the Navy, APL shared honors with many associate and subcontractors who had worked under our technical direction in its development.

We are presently engaged in missile assignments of a highly advanced nature which cannot be divulged for security reasons. Suffice it to say that, as always, our work is of such vital importance and urgency that little is spared to facilitate its progress. Scientists and engineers at APL are in the vanguard of science and enjoy the keenest sort of responsibility and challenge.

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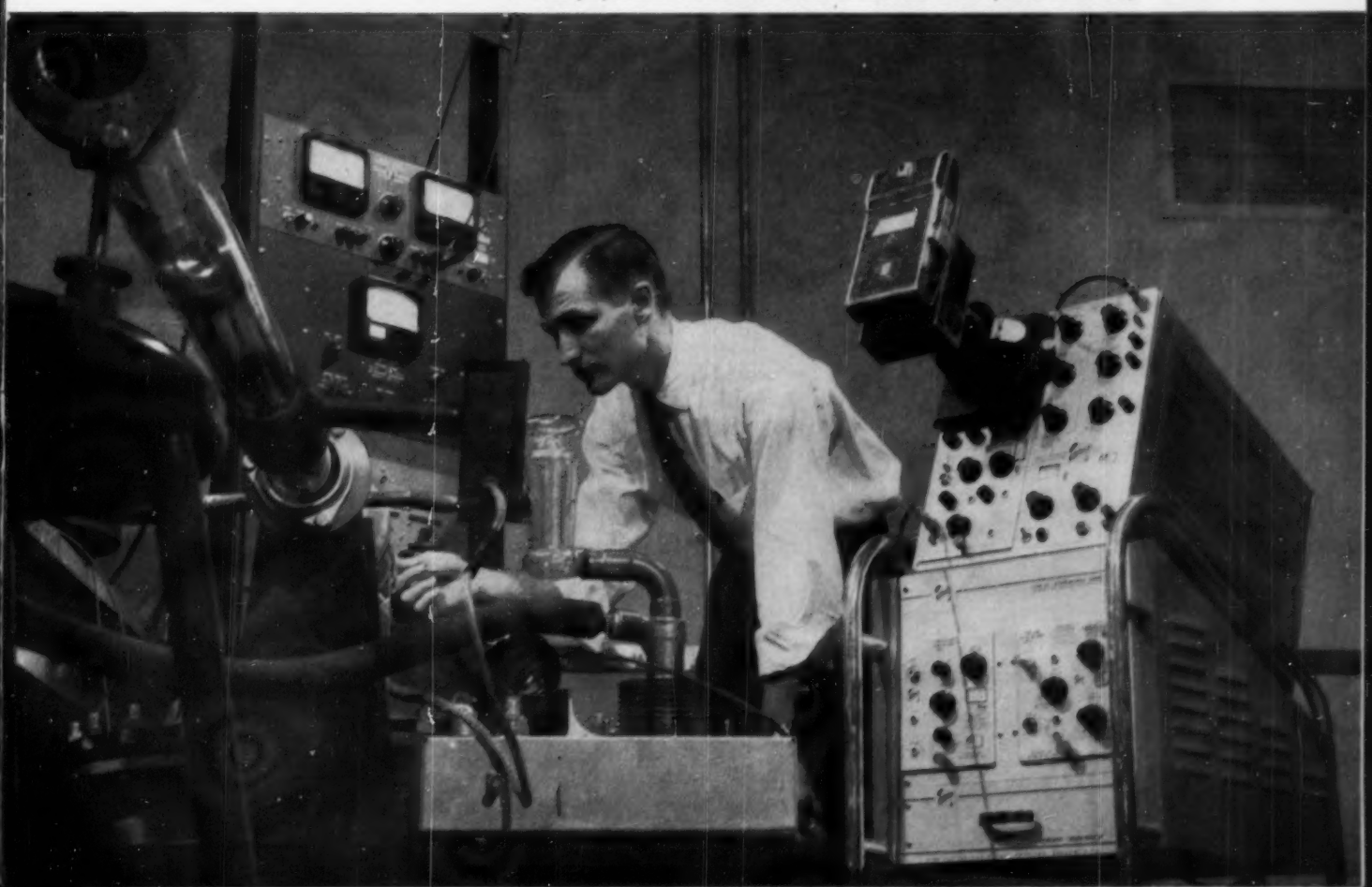
Advanced Study Program physics student J. T. Naff charges up the condenser of a high velocity shock tube preparatory to firing. Naff, a graduate of Louisiana Polytechnic Institute, is working on his Master's Degree at the University of California, while employed at Lockheed's Palo Alto Research and Development Laboratory.



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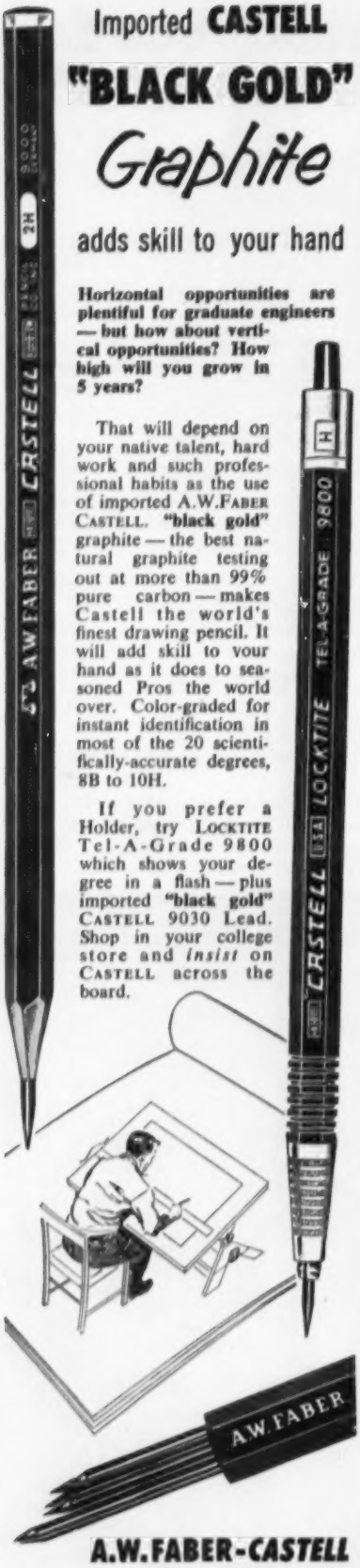

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Table of Contents

Silicones: The Untouchable Polymers 13
by Roy J. Lamm, ChemE '61

What's Become of the Automotive Gas Turbine? 16
by Edward M. Krech, Jr., ME '55; BPA '58

Civil Defense/In the Missile Age 20
by Harold S. Woodward, MCE '23

Perfection at Low Temperatures 24
by Allan R. Hoffman, EP '59

President's Message 32

Alumni Engineers 33

Fifty Years Ago in *The Engineer* 35

College News 40

Research at Cornell:
Professor Rydbeck Studies Solar Emissions 45

Technibriefs 48

Book Review:
Fundamentals of Mechanical Design 51

Stress and Strain 56

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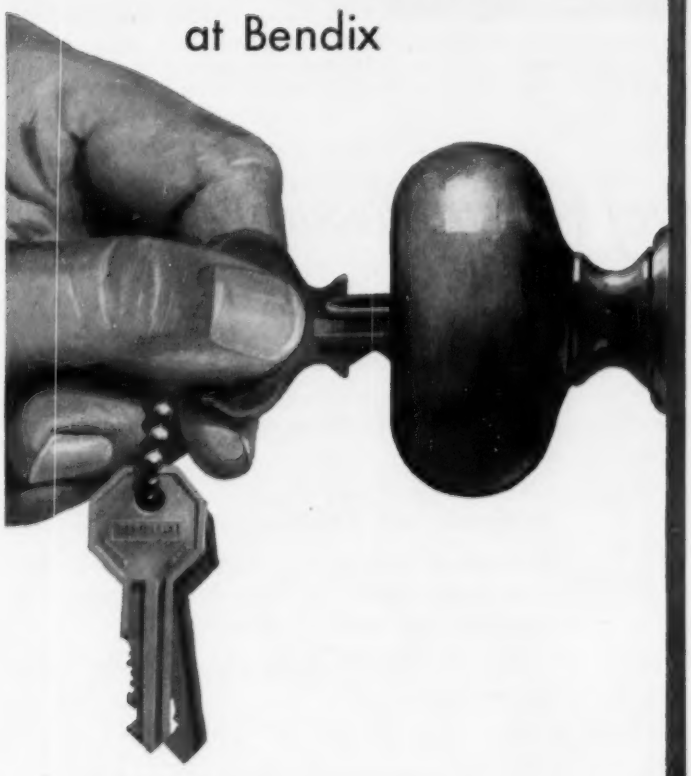

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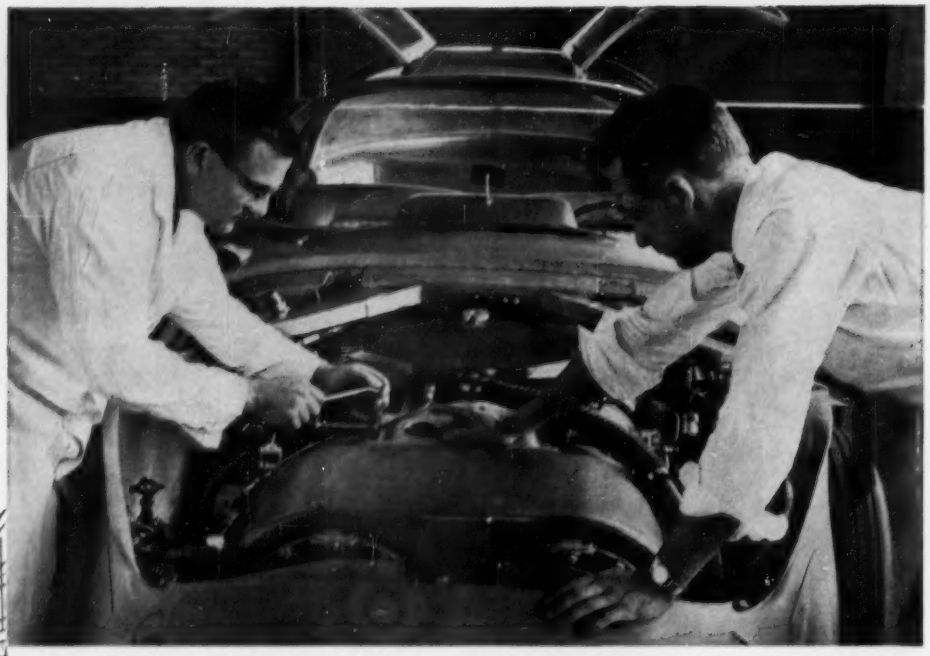

IMAGINATION AT WORK—Young GM Research Engineer Bill Ahrens, B.S. '52, M.S. '56, and Worth Percival (r.), Assistant Head of Mechanical Development at GM Research, working on the free-piston-powered XP-500 automobile. Bill is on the team studying the future applications of the free-piston engine.

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Sidney L. Simon

Dr. Sidney L. Simon
Assistant to the President

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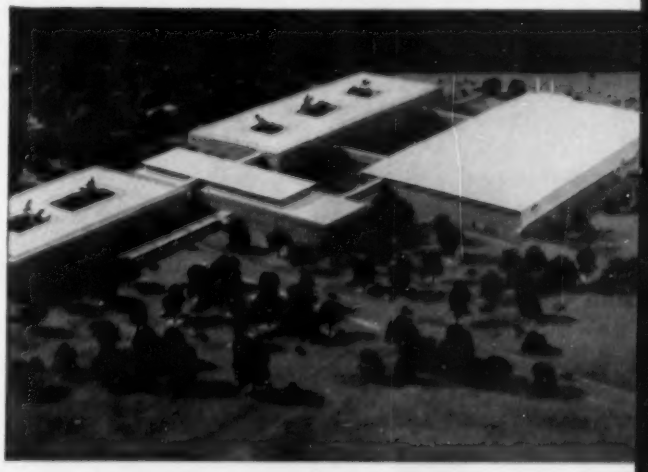

Pictured above is our new Research and Development Center now under construction in Wilmington, Massachusetts. Scheduled for completion this year, the ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

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Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

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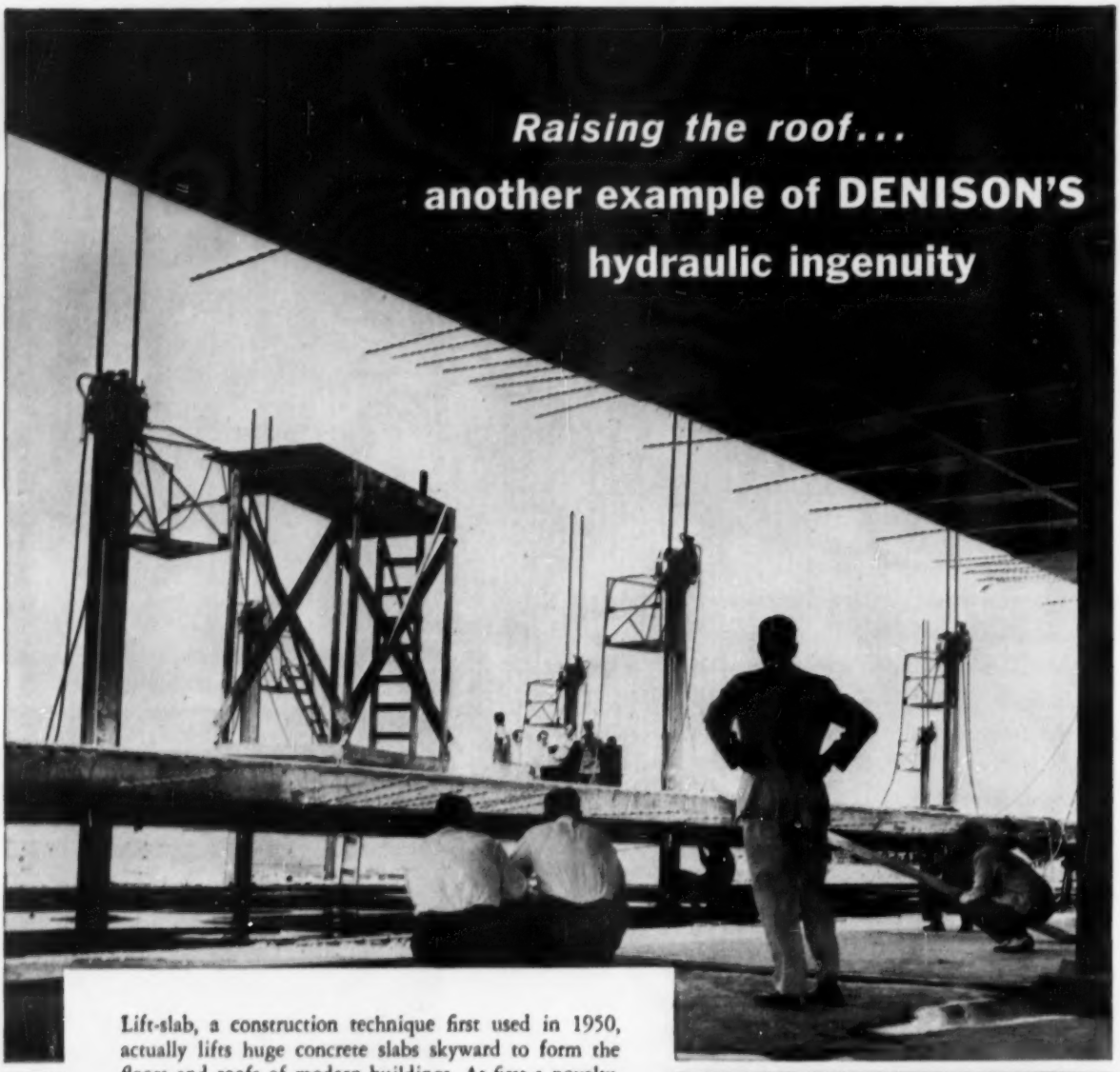

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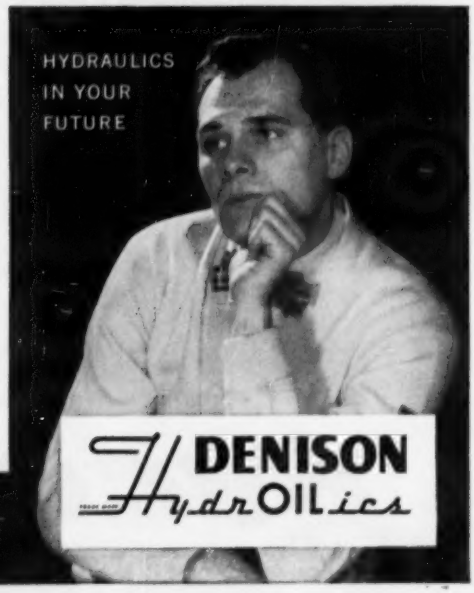

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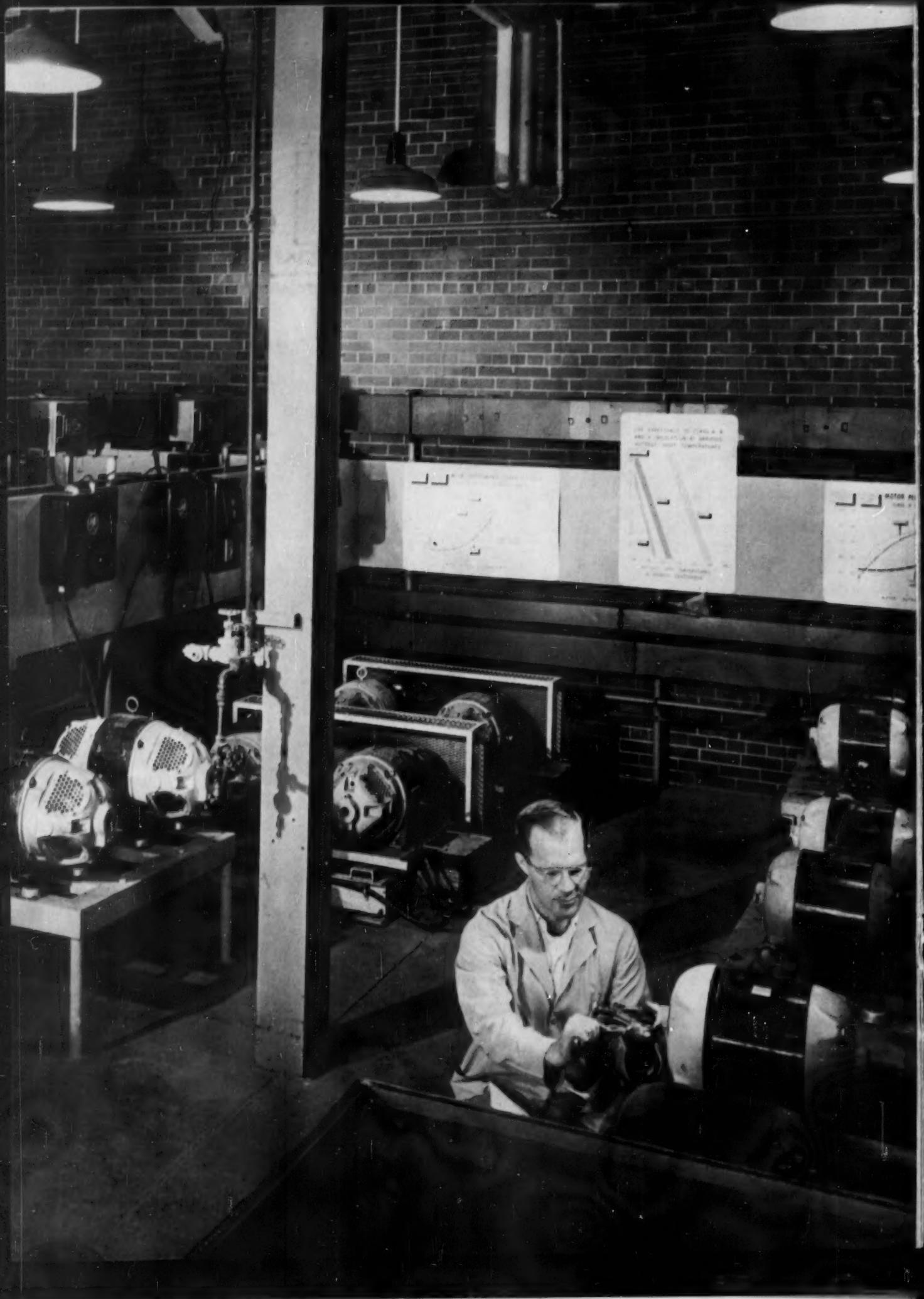


SILICONES: THE UNTOUCHABLE POLYMERS

by Roy J. Lamm, ChemE '61

A rapidly growing family of silicon containing liquids and solids today are finding their way from the laboratory into applications in industry and the home. This family has been given the general classification of silicones. The number of silicones, approximately two hundred at last count, reflect the number of applications where their unusual properties have proved superior to other engineering materials. These applications range all the way from electrical insulation in motors to auto polish for the family car.

New uses and new silicones are being developed daily by the three U.S. silicone manufacturers who have expressed their faith in these new materials with an investment of fifty million dollars in new plant facilities for mass production.

Technically speaking, silicones are chemical hybrids, crosses between organic and inorganic compounds of organo-silicon-oxide polymers. Silicones take numerous forms, depending on the use for which they were designed. Most, however, share the same molecular characteristics. Their molecules consist of long chains of alternate silicon and oxygen atoms. To each silicon atom two organic groups are attached. Schematically these chains are represented by: $\left[\begin{smallmatrix} R \\ O\text{-}Si \\ R \end{smallmatrix}\right]_X$ where "R" represents some organic group and "X" a number varying from six to two thousand. Since both the silicon and oxygen atoms are saturated (unable to bond with further atoms), and the R–Si bond has been shown to be exceedingly inert, it follows that the combination should be very stable under severe oxidizing and thermal conditions.

The specific forms of the two hundred silicones are obtained by varying the length of the chain and the organic groups attached.

Unique Properties

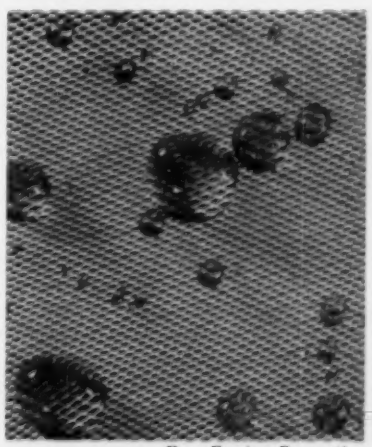
Generally speaking, there are five properties, present to a greater or lesser degree in all silicones, upon which one may base their value. These are: high dielectric strength, thermal stability, inertness, water repellency and rubbery quality.

Silicone dielectrics, related to quartz and mica in their molecular structure, retain good dielectric properties even after long term aging at high temperatures. A typical silicone resin designed for use in electrical insulation can withstand temperatures in excess of 200° C and maintain a volume resistivity of 6×10^{11} ohm-cm. It was this property that originally interested industry in silicones. Engineers had been searching for a heat resistant insulator that could be used for motor windings. Silicone rubber at the time appeared to be the answer. Research started and soon the other unusual properties of silicones became known.

The thermal stability of silicone oils and rubbers is exceptionally good. Rubbers can withstand temperatures all the way from a chilly −120° F to 500° F. Organic rubbers on the other hand will either crack or melt at such temperature extremes. Silicone rubbers, however, show very little change in hardness or elasticity.

The inert properties of silicones make them exceptionally useful in corrosive atmospheres. They show good resistance at high as well as low temperatures to such materials as concentrated acetic and hydrochloric acids, fifty per cent solutions of sodium and ammonium hydroxide and ten per cent solutions of nitric and sulfuric acids. Resistance to most oils and greases is equally good. For example, a sample of silicon rubber was immersed in ASTM #1 oil for seven days at 300° F with less than ten per cent swell at the end of the test.

Corona, weathering and ozone are taken in stride by silicone rubber unlike its organic cousins. Samples of silicone rubber were exposed to hot, humid weather conditions in a south Florida test station for ninety one months with no signs of cracking or crazing, even though the length of exposure was equivalent to twenty seven years of normal weathering conditions. The superior corona resistance of silicone rubber is demonstrated by



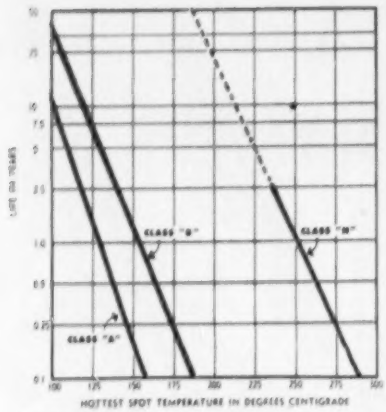
Dow Corning Corporation

Silicone's hatred for water is graphically demonstrated here—notice how the water droplets have formed tiny spheres touching the silicone-treated cloth at only one point.

←

***Frontice*—Class H Silicone wound motors are subjected to accelerated life testing in this motor test. Here silicone insulation is compared to organic insulation; here also silicone lubricants are tested. In the foreground may be seen a tank in which motors are subjected to extremes of humidity as part of the test cycle.**

Dow Corning Corporation



Compression set at temperatures from −70 to 500F for various materials.

such tests as placing a 14,000 volt stress on a test sample with no visible effects after 12,000 hours. A sample of organic rubber failed after thirty minutes.

Silicones hate water with a fury equaled only by a small boy at the wash bowl. While a little coaxing will bring the boy to wash, silicones will maintain their hatred of water indefinitely and never become wet.

The phenomenon known as wetting is due to attractive forces between the water droplets and the surface to be wetted. Silicones, however, exert little if any forces on water droplets. Thus the internal cohesive forces of the water droplets cause them to form little spheres touching a silicone treated surface at only one point.

This water repellancy of silicones should not be confused with the term water proof. A water proof material excludes both air and water. That's why rubberized raincoats, boots and rubbers are so uncomfortably hot to wear. Contrarily, a silicone treated material "breathes" while keeping water out.

The "anti-social" behavior of silicones is not just limited to water. The absence of attractive forces on a silicone treated surface prevent the adhesion of sticky materials. The anti-seize behavior of silicones, like their other unusual properties, has solved many problems in industry and the home.

Almost daily a new use for an existing silicone or a new silicone for an existing need is found by industrial researchers. A combination of two factors has brought about this multiplicity of silicones. Undoubtedly, their unusual properties have been the strongest force lengthening the list of silicones and applications. But these properties, however unique or desirable, did not sell themselves to cost conscious engineers or plant managers. Technical salesmen from all three U.S. producers have had to go to various industries, find out what their problems were and then go back and get their scientists or engineers to develop a silicone which would meet the need. Armed with the proper silicone the technical salesman had to then prove to the company involved that the use of the silicone would save them money.

Cooperation between producer and consumer does not end here, for after the silicone is bought, the manufacturer has to show his consumer how to properly use it for optimum results. Such technical service is costly—costlier than the service provided by any other segment of the chemical industry.

To discuss the places where silicones have been put to use would take more space than available here. A few major fields of application are certainly worth mentioning, since these fields at the present time account for the largest percentage of silicones sold.

Silicone rubber in gaskets, hoses and electrical insulation is today's big seller. Because silicone rubber maintains its rubbery quality for long periods of time at temperatures well below the point where organic rubber becomes brittle and above the point where organic rubber melts, it is being used in everything from seals on bomb-bay doors of jet bombers flying in air at −100° F to the gasket sealing the oven door in your kitchen.

Silicone rubber hoses are being used in our far northern air bases to carry hot air needed to start jet air craft. When not in use these hoses lie on ground at a temperature of −65° F. In seventeen seconds after they are called to use their temperature is 600° F. Yet, these hoses are standing up indefinitely.

The U.S. Army Nike rockets, defending our urban areas from air attack, are being equipped with silicone rubber hose which must carry ninety per cent hydrogen peroxide. This powerful oxidizing agent has no effect on the hose.

Compression set, the deformation of a material under pressure at high and low temperatures, was a serious problem with organic rubber gaskets which would lose their seal in a short time under severe conditions of pressure and temperature. Silicone rubber has stepped in and solved this thorny problem, for as the graph illustrates silicone is far more resistant to compression set than organic rubber.

Electricity, the silent servant upon which civilization so heavily relies, is useful only if we can keep it on the right path. If allowed to stray it will destroy the wire that carries it. Insulation then is as important as electricity itself, for without it you have havoc in electrical equipment.

The harder a motor works the hotter it gets and the faster insulation breaks down. Unfortunately, ordinary insulations have thermal limitations. As the graph indicates the highest temperatures class A and B insulations can endure for reasonable lengths of time are 130° C. Class H insulation composed of silicone resins mixed with glass, cloth or asbestos is rated for hottest spot operating temperatures of 180° C. This rating is conservative, for if we take a temperature of 200° C the life spans of the three types of insulations A, B and H are respectively ten days, twenty seven days and eight years.

The use of silicone class H insulation allows safe overloading of motors thus increasing efficiency and promoting economy. As an example in a certain plant twenty, forty horsepower motors were becoming overloaded due to an increase in production. Something had to be done before a failure and fire resulted. The motors were rewound with class H insulation and safely rerated at sixty horsepower.

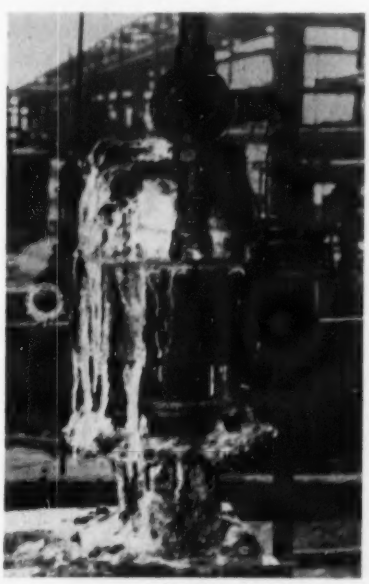
Next to heat, high humidity and corrosive chemical atmospheres are the biggest enemies of electrical insulation. However, motors wound with class H insulation have undergone such severe tests as operating at 250° C in an atmosphere of 100 per cent humidity under a spray of salt brine and oil with no change in horsepower. Even after the stator

from one of these motors was dropped three feet to a concrete floor the flexible silicone insulation remained unharmed.

Water while necessary for washing, drinking and cooling is a costly nuisance for masonry exposed to the weather. Brick and concrete appear to be very solid materials, but they really are honeycombed with tiny air spaces. Under a microscope masonry looks like a sponge and when exposed to water it acts like one. Water will fill these spaces and eventually go right through the masonry. The result is cracked plaster, damp walls and peeling paint. If the outside temperature drops below thirty two degrees the entrapped water freezes and expands, causing small chips to fall off the external surfaces.

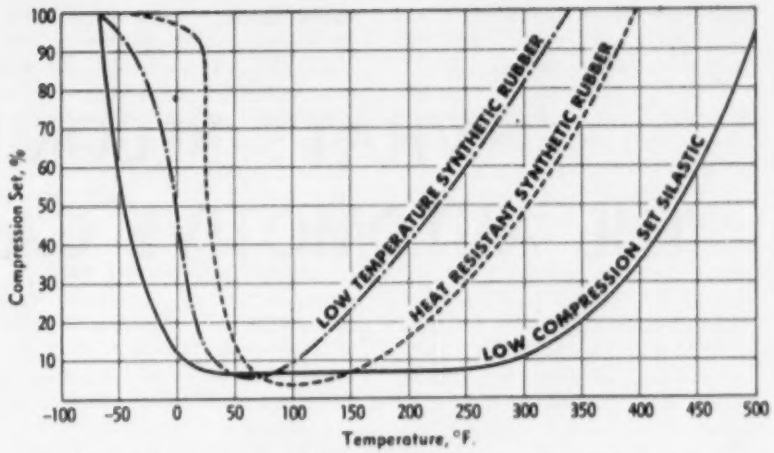
One of the best solutions to date for these costly problems is to keep the water from entering the masonry with a coating of hydrophobic silicone. A solution of silicone and solvent is sprayed on a wall or highway. The solvent soon evaporates, leaving the silicone soaked into the pores of the masonry. The rest is easy, for air can get out of the masonry, but moisture can't get in.

Similarly, silicone based paints are protecting such structures as



Dow Corning Corporation

The capacity of 22 of these mixing pump motors was increased 50% with silicone insulation, at a total saving of over $2,100 over the new-motor cost. Exposed to outdoor weathering and to a variety of soluble salts, their frequency of failure has been reduced at least 24 times.



Life at various temperatures for Class A, Class B, and Class H insulation.

cracking towers and furnaces exposed to the weather. The surface temperature of such equipment is usually too high for lasting protection by even the best organic paints. But silicone's thermal stability combined with its water repellancy is filling the bill.

In one way or another we've learned how to put things together and make them stick. But little has been done in the opposite direction, that is, developing materials to prevent sticking. In the past oil, grease and soap have been used in molds to keep the molded product from sticking. These substances would release a certain number of tires or loaves of bread and then either melt or burn away. Silicones "anti-social" behavior coupled with their thermal stability were the ideal solution. So much so that today almost all the tires made in the country are released from molds sprayed with silicone. Since the innovation of silicones tire manufacturers report that mold cleaning and maintenance have been reduced by ninety per cent.

Silicones are excellent dielectrics, but with proper treatment plus carbon black and other materials they become electrical conductors. Silicone rubber so treated is now being used as electrical cable on our atomic subs. The Navy specified silicone cable, because in case of fire aboard the sub the ash from the burnt cable would remain a conducting medium. The vital functions of the sub could then be continued.

Silicone conducting cable will soon appear in the ignition wires of the higher priced automobiles. This action was taken by auto makers to eliminate the use of suppressors, which are needed in the normal ignition system, using copper wires, to keep static out of the auto's radio.

Mass Production Costly

Silicones are not cheap. Most of them cost between three and four dollars a pound. Although this is only half the price they were ten years ago, they still are not in a competitive position pricewise with other materials. They must rely on their superior long range performance for consumer attraction. Too often they are "engineered away" by an inferior product which offers a short term economic gain.

Production of the polymer accounts for the high price. The multiplicity of steps, mediocre yields, and costly corrosion resistant equipment are the major deterrents to economic production.

The Gringard process is one of the methods most widely used today. It consists of the deoxidation of sand with coke to yield elemental silicon. The silicon is then chlorinated to $SiCl_4$ and reacted with an alkyl gringard to yield an alkyl chlorosilane. This is hydrated with water and then condensed forming the desired polymer.

Research and engineering are continuing in an effort to reduce the cost of production while simultaneously increasing the market for silicones. Undoubtedly the combination of these two factors will soon make silicone polymers as popular as they are untouchable.

WHAT'S BECOME OF THE AUTOMOTIVE GAS TURBINE?

by Edward M. Krech, Jr., ME '55; BPA '58

A few years back one of the biggest topics of interest around major automobile manufacturers was the automotive gas turbine. One could hardly open a technical magazine without being faced with a glowing account of this "power of the future" and the general tone of the articles was that the reciprocating engine was well on the way towards the shelf alongside the hand starting crank and the long duster. Now suddenly within the last year or so there has been a relative dearth of this propaganda. What does this mean for the future of the automotive turbine? Has it proven a fizzle or is the industry just keeping quiet until they're ready to spring the big surprise?

Actually it looks like it's a little bit of both if this could be thought possible. Each of the "big three" has developed and built a workable turbine but refining the operating characteristics and solving the production problems has proven to be a horse of a different color. The general impression now is that development is still being done on the turbine but that things have settled down to the point where everybody can almost be said to be running just fast enough to hold their position in the industry. In order to fully understand the current position of the automotive gas turbine, the problems involved, and its possible effect on the industry, it is necessary to delve briefly into its technical and historical background.

Mechanics of Operation

The gas turbine operates basically on the principle of the open Brayton cycle. Intake air passes first into a compressor where its pressure is raised to three or more times its former level. From here the pressurized air continues into the combustion chamber where it is mixed with fuel and the mixture burned at constant pressure causing terrific expansion of the gases. Part of this energy is then lost in the turbine which acts as the power unit for the inlet compressor but the rest is available to provide the thrust of the conventional jet engine in the form of large quantities of hot exhaust gases. Obviously propulsion by hot exhaust gases would be impractical for the average family car so it is necessary to use a second or drive turbine to absorb the energy of these gases. Power from this second turbine is then transmitted to the wheels through a more or less conventional transmission unit.

The basic idea of the gas turbine is far from new but technical problems, chiefly in the field of high temperature metallurgy, kept it from being developed until relatively recent years. The first wide application was the turbojet engine for aircraft towards the end of World War II. After the war and the subsequent retooling rush was over the big automotive companies began to jump on the bandwagon and start their own research programs inquiring into the possibilities of the gas turbine for automotive propulsion. Several other companies, including Boeing Airplane Company, also did work on smaller turbines, including automotive, but the main bulk was soon taken over by the big three of General Motors, Chrysler, and Ford. As the work progressed the relative advantages and disadvantages of the gas turbine became increasingly apparent.

Advantages of Turbines

The gas turbine possesses terrific potential for high power output in a relatively light package. This high horsepower to weight ratio makes it ideal for such as application as rear engine mounting, not possible with heavier engines due to the balance problem. The final weight should run between a third and half that of a conventional reciprocating engine.

The purely rotating motion of the gas turbine eliminates to a large extent the vibration problems inherent in the piston engine. It also results in smoother transitions from one speed range to another. The number of moving parts is greatly reduced to about one-fifth

that of the conventional engine. Lower maintenance costs should result and certainly the lubrication problem is simplified considerably.

The gas turbine is relatively non-selective in its choice of fuels resulting in a reduction in the problem of matching fuels and engines currently faced by the automotive and petroleum industries. Octane rating would be no problem since the gas turbine inherently eliminates knock and the high air-fuel ratio results in a relatively clean and odorless exhaust.

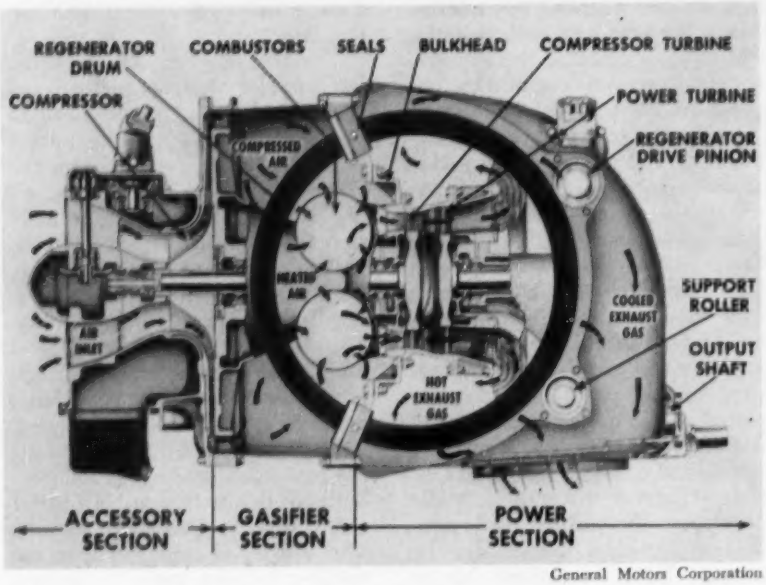
Many Problems Not Solved Yet

Now what about the negative side of the question? Two problems immediately stand out ahead of all others. They are: the very high continuous temperatures involved, particularly in the turbine blading, and the relatively low fuel economy as compared to the conventional piston engine. In the aircraft turbine the temperature problem was, and still is, largely solved by the use of high alloy metals, generally with a high nickle-cobalt content. However, this is impractical in the automotive industry due to the very high cost and relative scarcity of these metals making any large scale use of them impossible. The problem then is the development of a low cost, plentiful, high-strength material capable of withstanding high temperatures and easily amenable to mass production methods. The Ford Motor Company has been working on a high nitrogen, chrome-manganese steel to meet these requirements, but so far the heat treatment has proven quite difficult and expensive. Another possibility being explored, is the use of ceramics or a sintered compact of powdered metals and ceramics known as cermet. Whatever material is finally developed, the turbine blade production problem must also be solved. Up to the present, blades have been individually machined but this is again impractical from a mass production standpoint, particularly when one considers the thumbnail size involved. Efforts have been made to cast all the blades in one section with some success, primarily by Chrysler, but there is still work to be done along this line.

The poor fuel economy is caused by the fact that no turbine can hope to extract anywhere near all the available energy from the hot expanding gases coming from the combustion chamber. This is not undesirable in the aircraft turbojet since these exhaust gases provide the terrific thrust for propulsion, but with the automotive turbine this is just energy thrown away. Thus early in 1954 when General Motors came out with its 300-horsepower GT-300 and GT-302 turbines mounted in a bus and in the headline making Firebird I respectively, the fuel consumption was found to be more than twice as high as for comparable reciprocating engines. The answer, of course, was to use the hot exhaust gases to preheat the incoming air thus increasing overall efficiency and providing a cool exhaust in the same step. When Chrysler sent a Plymouth powered by a gas turbine across the country in March 1956 this process, known as regeneration, resulted in a vastly improved fuel

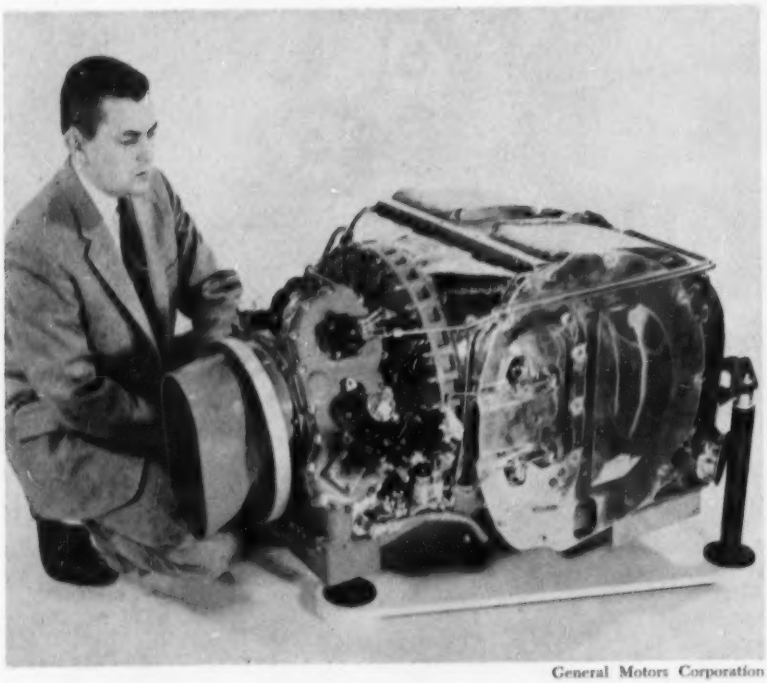
General Motors Corporation

Left front three-quarter view of engine and chassis, General Motors Firebird II, experimental gas turbine automobile (shown on cover).



General Motors Corporation

Schematic arrangement of the GT-304 Whirlfire gas turbine engine in the Turbo-Titan.



General Motors Corporation

Overall view of the Whirlfire engine.

economy of about thirteen to fourteen miles per gallon. This represented the first practical test of the gas turbine in a passenger car and, although the engine was only 80-horsepower, comparable to a 1939 Plymouth, it represented a big step forward. At the same time General Motors came out with the Firebird II, an all-titanium body, aerodynamically shaped car, powered by the GT-304 Whirlfire gas turbine with a design rating of 200-horsepower at 35,000 rpm. The use of regeneration cut fuel consumption fifty percent over Firebird I bringing it within range of the conventional engine.

This period represented the time of maximum optimism in the industry and considerable publicity about the automotive turbine resulted. With success apparently so near what happened and what is ahead for the future?

One of the biggest difficulties is that the regenerator, while it largely solved one problem, created another almost as troublesome. In order to perform its function effectively the regenerator must allow for the transfer of a tremendous amount of heat in a short period of time, and for automotive work, while occupying a minimum of space. This is effectively accomplished by what essentially amounts to a rotating drum with a fine grid-like structure that alternately passes through the hot and cool gas streams. Unfortunately, the adaptation of this regenerator to mass production methods resulting in a reasonably priced piece of equipment is practically impossible. This problem has actually reached the point where the regenerator may be abandoned and some other method of increasing fuel economy developed. A process of intercooling is under consideration as are other methods kept confidential by the industry.

Automotive Turbine's Future

These, then, are the problems behind the present relative stalemate —development of a satisfactory alloy and production methods for the turbine blading, and development of a production method, or an adequate substitute, for the regenerator.

All these facts point rather strongly to the likelihood of the gas

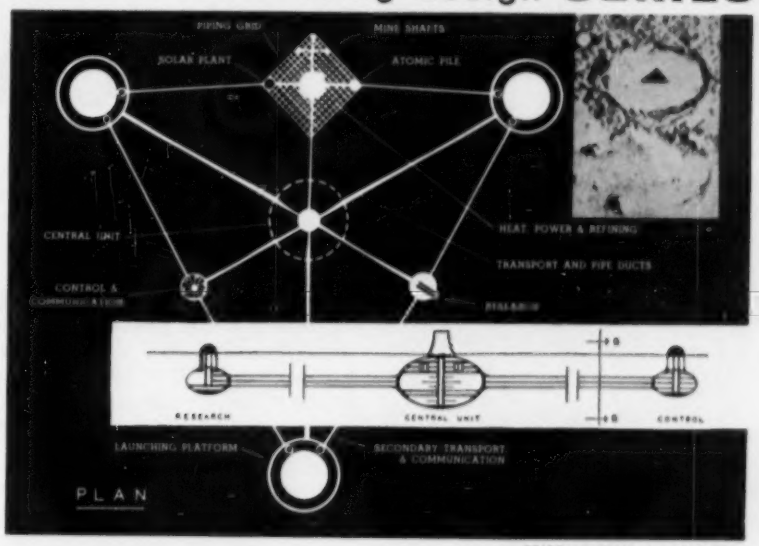
turbine taking over by evolution rather than revolution. Long-haul high-speed trucks and buses will probably be one of the first major users of the turbine since it operates most efficiently under full-power maximum-speed conditions. General Motors has been test running its Turbo-Titan, a heavy-duty Chevrolet truck-tractor fitted with the 200-hp GT-304, extensively this year with this market in mind. The high first cost of this type vehicle should be able to absorb the high cost of the initial quantity production attempts of the turbine more easily than could a cheaper car. There is also more space available in a truck or bus allowing for a larger and thus more simplified and cheaper regenerator.

When the move finally comes for turbine propulsion in passenger cars, the first models to adapt the system will be the luxury lines for many of the same reasons outlined above. Buyers of these models such as Cadillac, Lincoln, and Imperial have not the same concern for initial cost and fuel economy as the Chevrolet, Ford, and Plymouth owners. Then, as production methods and materials improve, the gas turbine as a propulsive unit will gradually be picked up by the low priced models.

All these developments take time. Using General Motors as an example, a major change such as this must first be developed and studied by the research staff, then passed on to engineering staff for complete restudy and road tests, and finally sent to the line divisions for the final decision and production. Much retooling and reorganization will have to be done before the actual work begins. It is then safe to say that there is little possibility of large scale usage of the gas turbine for the next four or five years at best.

Thus it can be seen that, while gas turbine development is currently at a dip, industry is alert and working on its possibilities. There are many problems to overcome, competition in the form of the conventional and free piston engines to beat, and a time lag to wait for. There can be little doubt however, that the gas turbine, with its many inherent advantages, will still figure strongly in future automotive propulsion.

MARS outstanding design SERIES



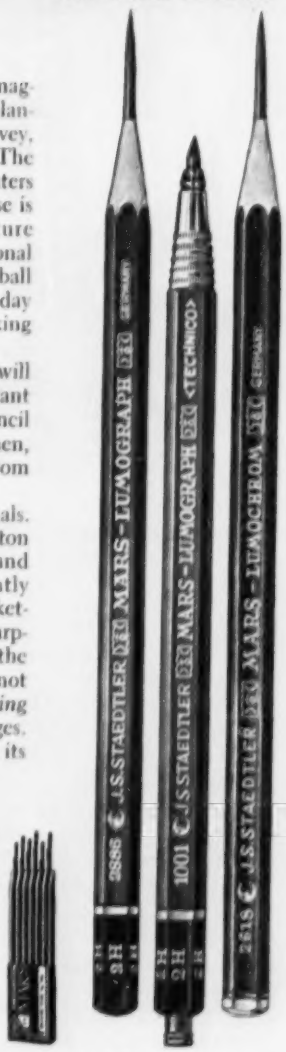
SCALE OF PLAN: 1" = 800 FT.

lunar base

Tomorrow's realities depend on research and imagination today. Both were used extensively in the planning of this lunar base designed by William G. Harvey, Jr. to accommodate space ships and travelers. The suggested location is "Aristotle," one of the craters near the north pole of the moon. Most of the base is beneath ground level to minimize temperature changes. Living quarters are spacious and recreational facilities include a swimming pool and basketball court. Power is supplied by solar plants during the day and atomic pile at night. Research, living and working areas are joined by monorail subway.

No one can be sure which of today's new ideas will become reality tomorrow. But it will be important then, as it is now, to use the best of tools when pencil and paper translate a dream into a project. And then, as now, there will be no finer tool than Mars—from sketch to working drawing.

Mars has long been the standard of professionals. To the famous line of Mars-Technico push-button holders and leads, Mars-Lumograph pencils, and Tradition-Aquarell painting pencils, have recently been added these new products: the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman's" Pencil Sharpener with the adjustable point-length feature; and—last but not least—the Mars-Lumochrom, the new colored *drafting* pencil which offers revolutionary drafting advantages. The fact that it blueprints perfectly is just one of its many important features.



The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom colored *drafting* pencil, 24 colors.

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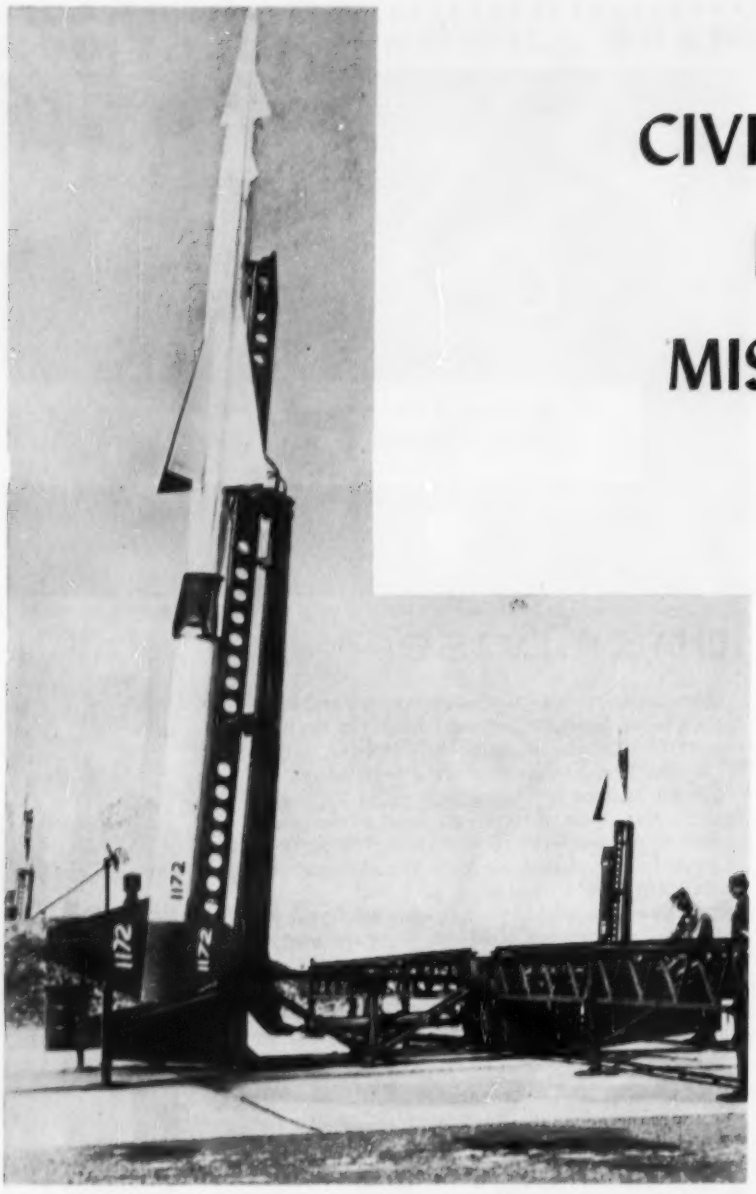


CIVIL DEFENSE IN THE MISSILE AGE

by
Harold S. Woodland,
M.C.E. '23

Now that the intercontinental ballistic missile appears to be a reality, the problem of protection for our population is being re-evaluated. If all aspects of the problem are considered, anyone could be excused if he considered a solution unlikely, improbable, or even impossible. For in addition to physical protection there are psychological, social, and economic aspects which have a vital bearing on the subject. With all these factors involved, it should come as no surprise that the solutions are about as numerous as the individuals trying to supply the answers. Whatever decisions are finally made, they will at best have to be compromises, with plenty of guesses as to so-called "calculated" risks.

In the first place it is impossible to make a precise analysis of any particular area in case of nuclear attack. The obvious variables are the aiming point, the yield of the weapon, height and nature of the burst, bombing errors, topography, weather conditions and future weapon designs. The two categories of protection at present may be summarized as "distance" and "shielding." It now looks as though the "distance" category is becoming a less practical one because of the time element. We are thus left with the "shielding" or shelter category.

Civil Defense is a bureau of the government that at present is not viewed with any degree of interest by the public. We have not been bombed in two world wars, so we are not particularly alarmed at a future possibility that may not occur. Other countries who have experienced these catastrophies have a different outlook and realize to a greater degree the necessity for a protective organization. Scandinavian nations are already making

widespread use of underground dual-purpose shelters – structures which can be used for commercial purposes and still be converted into shelters. The arrival of the first bomb on our territory would change this apathetic attitude at once.

Few will disagree with the idea that an organization such as Civil Defense is a necessity in these times. We should certainly make all efforts to plan for an attack. And what could have a higher priority than ultimate survival of this country's population and industry. With this admitted we are confronted with the complex problems of where to start and what to do first.

Present Planning Inadequate

When plans were first drawn up for Civilian Defense in the pre-missile era some few hours of grace from early warning were counted on for evacuation of the population from our large cities. It was hoped that we might have time at least to evacuate the children. Now with the advent of the I..C.B.M., warning time has disappeared and along with it pre-evacuation. Evacuation should still be considered to some extent in over-all planning. The people that are in the area of the first bomb are unfortunate, but those in other areas believed to be targets might be able to partially evacuate those areas. If the first bomb arrives with little or no warning in a populated area, we will suffer an enormous number of casualties before any protective action can be taken.

After the first nuclear weapon has arrived, what then? Should people take shelter or try to get out of the area before the next one is dropped? A good many consider that any degree of evacuation from our large cities would be impossible due to bottlenecks, breakdowns, accidents and general confusion that would ensue. The chances are few that much time would elapse between shots. If so the answer does not lie in evacuation but in convenient shelters.

At the present time the F.C.D.A. planning is based on so-called assumed aiming areas. They are 314 in number and comprise about 40 percent of the population. Aiming areas are defined as "that geographic area within which it is assumed an enemy would most probably place one or more nuclear weapons to assure the accomplishment of his mission, in the event that such mission was the destruction of the target." This aiming area is basic for Civil Defense planning in that certain facilities such as shelters and supporting survival resources should be located in the area, while others, such as a permanent emergency control center and emergency hospitals should be outside the area. The design of the shelters would also be based on their locations within or without the area.

Safe Shelter Standards

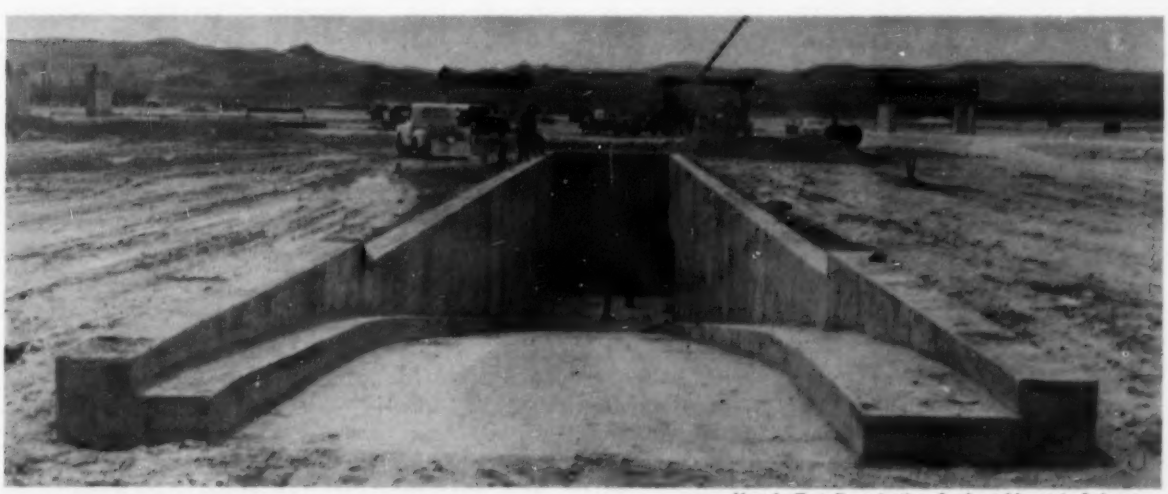
The latest recommendations are for a shelter in the area twenty miles from the aiming area boundary. The plan at present is to locate shelters outside the aiming area. The specifications for these shelters are six feet eight inches of earth cover or four feet six inches of concrete. It is also recommended that provision be made for occupancy of fourteen days. This means mechanical ventilation with filtered air, emergency lighting, water supply, sleeping and sanitary facilities, and food storage facilities.

The recommendations for rural areas more than twenty miles outside the aiming area boundary are for fallout shelters. These would require a cover of three feet of earth or two feet of concrete and would have to be provided with almost

ABOUT THE AUTHOR

Harold S. Woodward received his civil engineering degree in 1922 and his master's in civil engineering a year later from Cornell. Mr. Woodward, active in the New York State Civil Defense Administration, was an eyewitness to the "Priscilla" atomic test shot, the fifth in last summer's series, at the Atomic Energy Commission's Nevada test site.

It was during this test that the shelters discussed by Mr. Woodward in his article were tested. In addition to his work in civil defense he is active in the ASCE, American Concrete Institute and the Cornell Club of New York.



Nevada Test Organization, Lookout Mountain Laboratory

Automobile ramp leading down to entrance of the underground dual-purpose garage and mass shelter, sponsored by the Federal Civil Defense Administration. The structure was tested at a pressure range of about 30 p.s.i.

Nevada Test Organization, Lookout Mountain Laboratory

Rear view of steel-reinforced concrete home shelter designed by Federal Civil Defense Administration. A temporary steel cover for the escape hatch (bottom) was blown off and the passageway partially filled with dirt. Exit through the passageway can be accomplished, however. Removal of another door, which is designed to protect the interior against blast and radiation, at the bottom of the escapeway, plus the angle of the pipe, would drop the dirt or debris into the underground room, permitting exit by occupants.

the same equipment as the other shelters.

As anyone can see, these recommendations are very costly and the probability of getting appropriations for this kind of program appears to be slight at present. Still, a start should be made somewhere if an effective program is to be accomplished at all.

It has been suggested by some that new structures of the industrial or commercial type be built for *some* amount of blast pressures applied to the superstructures.

However, the large pressures recommended for design (thirty p.s.i. at present) make this impracticable from an economic standpoint alone. Even a third of this value would give ten p.s.i. as against a customary one eighth p.s.i. wind value. Not only should the building frame be designed for this pressure, but also the articulated parts of the structure such as the exterior walls, windows and doors. One can imagine glass and window frames designed for this pressure. We would end up with heavy concrete windowless boxes for buildings. And if we design for say ten or twenty p.s.i. now, who knows what it would have to be a year or so hence with developed weapon changes. This suggests the next item.

The present architectural trend is to all glass buildings. This is exactly the reverse from any standpoint of shelter. Ordinary glass shatters at less than one p.s.i. Present building design of this nature would make a casualty of practically everyone in the building above the ground floor. Look at the modern schools with practically all glass walls. By their nature the majority have little lateral stability and would probably collapse at any pressures approaching one p.s.i. It would be necessary to outlaw this type of building.

A third reason that protective measures for new construction of buildings would not solve the long range problem in the larger cities is that the big majority of people will still be working or living in the older type buildings. When we talk of making provisions in new construction, we are hardly making a start at a solution, except in the rural areas.

Shelter Locations

From this discussion it appears that the only logical shelter would be underground. With this conclusion we come to the next problem. Should shelters be built in the so-called aiming areas, or should we write off the aiming areas and build shelters on the fringes? In other words, we are saying that the city areas have little chance of survival and that the majority of the people are lost. If this is the case, the whole program looks pretty hopeless to start with. How will the people in these areas feel? Will they be willing to see all expenditures for protection go to their country neighbors, while they are left like a sitting duck? Also we could guess at what the fringes might be today, but next year they might be pushed back a few miles. We might also contemplate the chaos ensuing after the first bomb is dropped on New York, for example, with one third the population casualties and the remainder trying to reach some shelters ten miles away.

The Civil Defense Administration has made numerous tests on shelters under atomic detonations. In the test made on June 24, 1957 mass shelters were tested for the first time. Four large mass-type shelters were built. These consisted of a dual-purpose underground garage and shelter, approximately 90 feet square under three feet of earth, and three dome shelters, each 50 feet in diameter, built with the dome exposed above the ground. The dome consisted of a six-inch concrete shell. The latter were tested at varying distances from ground zero subjecting them to pressures of twenty, thirty-five and seventy p.s.i. The dual purpose shelter was tested at about thirty-five p.s.i.

The results of the tests were that the high-pressure dome failed as expected, the medium-pressure dome failed, but did not collapse completely, while the low pressure dome showed no signs of structural failure. There was no failure of the dual purpose structure itself, but the wall of the ramp facing the blast was damaged.

If we are serious in getting some sort of shelter program under way soon, we will have to make a start without the appropriation of billions of dollars. For politically, a multi-billion dollar program would not have a chance at present unless our nation's whole outlook is changed over night. But a few things could be done which would be relatively inexpensive, useful, and necessary to get a larger program underway.

Each city should have a study made of all underground facilities which might be used as shelters. Subways in the larger cities should be studied in detail. Such additions as baffle walls at entrances, movable

Nevada Test Organization, Lookout Mountain Laboratory

One of three concrete domes tested by an atomic detonation. The domes were designed and located for tests of pressures ranging from about 20 to 70 p.s.i.

bulkheads in certain locations, renovation of unused spaces, and many other improvements might be made to get a large, convenient, and adequate shelter area. No doubt there are many buildings, especially older ones, where floor slabs of a heavy type were used which would provide adequate protection. Many garages and underground warehouses might be available. In a city such as New York it would probably be surprising the amount of space that would be obtainable at relatively little expense.

New construction undertaken in slum clearance or low cost housing developments might also be a major consideration. In these projects most of an entire city block is usually excavated for basements and foundation walls. This whole area could be converted into shelter space and used for garage facilities. This would at least provide shelter for the tenants of the development and possibly for many more. If site conditions made it feasible, more than one level could be built underground. Of course, the Federal Government would have to pay the difference in cost to make this possible.

Outside the large cities we could provide fallout shelters in conjunction with new school, industrial and public buildings. These shelters should all be dual-purpose, useful structures for peacetime use. There are many school sites where basement areas may be added at small additional expense with the addition of a heavy concrete slab above for protection. These rooms may be used as cafeterias, recreation spaces, and even shops and classrooms. Here again the Government would have to pay for the added cost.

If a program is to be put into effect it is important that the Government itself lead the way by following the adopted requirements for its own buildings. Up to now this has not been done, probably due to doubt concerning definite recommendations and the additional cost involved. It is impossible to "sell" private owners, school boards, and public agencies a program which the Government itself ignores.

Contrary to the belief in many other countries, we have a limited supply of funds. Government officials have to decide which programs have priority. They have to decide in this particular field of Civil Defense whether priority should be given to international agreements endeavoring to outlaw the use of nuclear weapons, or to allocate the funds to the development of defense measures involving interception of missiles.

What is needed is the experienced judgment of technical men who can reach reasonable decisions that are feasible to project into a program. The engineers of this country are such a group of men. If time and thought are given to this vital problem in generous amounts our nation will remain safe.

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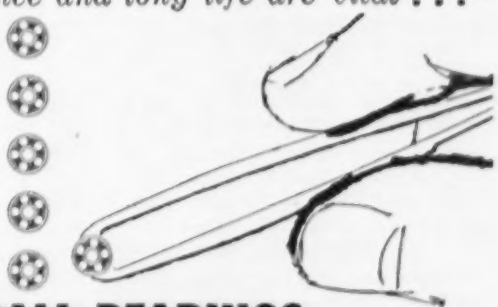

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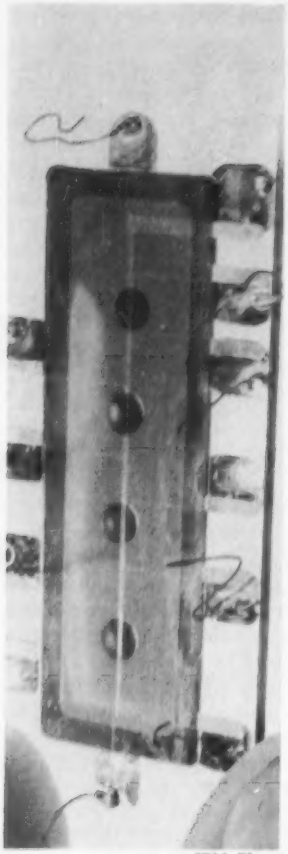


IBM Photo

Persistent circulating currents occurring in super conductive materials are being used as a means of storing information. Pictured here is a four cell low temperature memory element.

PERFECTION AT LOW TEMPERATURES

by

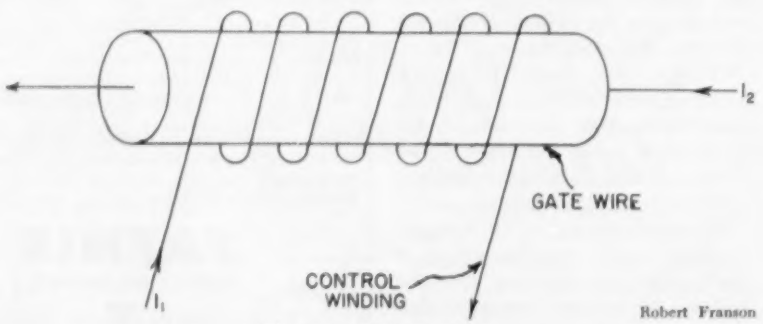
Allan R. Hoffman, EP '59

An experiment at MIT, in which an induced current of several hundred amperes has been flowing in a closed lead ring for several years without any measurable change in the current magnitude, has provided vivid proof of the existence of a state of matter in which no resistance to current flow is exhibited. This state, called the superconductive state, was first observed in the early nineteen hundreds, but only in the past few years has an attempt been made to utilize superconductive properties in commercial devices.

Superconductivity was discovered in 1911 by H. Kammerlingh Onnes, three years after he succeeded in liquifying helium. While investigating the electrical properties of several conductors in this low temperature region, he discovered that the resistance of mercury dropped sharply to zero at 4.12° K. Subsequent investigations on other materials revealed that niobium becomes a superconductor at 8° K., lead at 7.2° K., plus many more. All together, 21 elements plus alloys were found to be superconductors, with transition temperatures ranging between 0.5 and 19° K.

Besides being temperature dependent, the superconductive threshold is dependent upon the magnetic field the superconductor is subjected to. A plot of the critical magnetic field versus the temperature at which a material's resistance drops to exactly zero shows a distinct separation between the superconductive and normal states.

If the temperature is held below the transition temperature for one



Robert Franson

Figure 1, Single Cryotron

of these materials, the resistance of that material is zero. Its resistance will remain zero until the applied magnetic field reaches a critical value above which normal resistance returns. If the field is lowered the resistance disappears. If we operate at a still lower temperature the required magnetic field to restore normal resistance is greater.

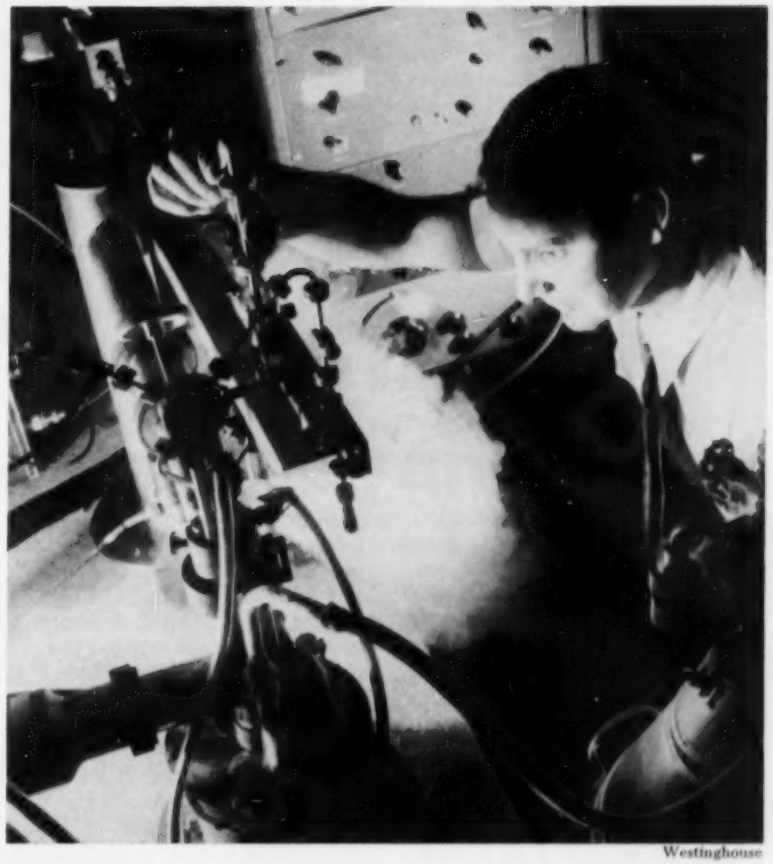
The Cryotron

These principles are utilized in the operation of a device called the cryotron. In the early cryotrons the resistance being controlled was a straight tantalum wire about one inch in length. The magnetic field was generated by current through a niobium coil wound over the central wire.

Figure one shows a schematic representation of such a device. The control winding is made of a material with a high transition temperature so that regardless of the magnitude of I_1 this wire will always be superconductive. The central (or gate) wire is a superconductor of lower transition temperature so that the magnetic field of the control winding can "pull" it above or below the normal-to-superconductive threshold.

The current I_2 carried by the central wire also produces a magnetic field at its own surface, which can cause a return to normal resistance. However, for a given value of current, the field produced by the control winding is greater than the self field produced by the gate wire. $H_{solenoid} = \left(\frac{N}{L}\right) I$ where $\left(\frac{N}{L}\right)$ is the number of turns per unit length in the coil. The self field $H_{sf} = \left(\frac{I}{\pi d}\right)$, where d equals the central wire diameter. Dividing $I_{critical}$ of the self field by $I_{critical}$ of the coil, one gets $\pi d \left(\frac{N}{L}\right)$. This quantity must be greater than one for the cryotron to be a useful device. If the current gain were less than unity, it would not be possible to control one cryotron with an identical cryotron, because more current would be required to bring the second cryotron to its control-current threshold than the first cryotron could handle thru its superconductive gate circuit. The quantity $\pi d \left(\frac{N}{L}\right)$ is called the cryotron current gain. It is the mathematical expression of the fact that a small current flowing in the control winding can determine the path that a larger gate current will take in a cryotron network. To see that this is possible, examine figure two. If the gate wire of cryotron (1) is resistive while gate wire (2) is superconductive, the current I will all flow through branch (2). However, if we make gate (2) resistive and gate (1) superconductive, the current I will now all flow through branch (1).

The magnetic field due to the control winding is parallel to the gate wire axis, while the self-field is tangent to the wire surface, i.e., the two fields add in quadrature. It has been found that regardless of the direction of the net magnetic field, when the magnitude of this vector sum reaches a certain value, the superconducting gate wire reaches its critical field. Thus, the cryotron has an interesting property as a circuit element. Control is independent of the sign of the control current, depending only on its magnitude. Furthermore, when the gate circuit is ON, i.e., in its superconductive state, currents can flow in either direction, unlike a vacuum tube which can pass current in only one direction.



Westinghouse

A research physicist uses ultra frequency microwaves to study the superconductivity of metals at temperatures less than one degree above absolute zero. Liquid helium is used to cool the metal sample.

Superconducting Materials

A most interesting property of superconductors is that when they cross the threshold into the superconducting region all magnetic flux previously present inside the wire is pushed out. This property, called flux exclusion, can be readily demonstrated by use of a bismuth probe around the specimen when transition occurs. The resistance of a bismuth wire is a function of the magnetic field the bismuth sees. As a result, if the bismuth probe is included as one branch of a Wheatstone bridge circuit, which is balanced at a point just above the threshold curve, as the threshold is crossed the excluded flux produces a change in the bismuth wire resistance, causing the bridge balance to be disturbed. If the superconductor passes back into the nor-

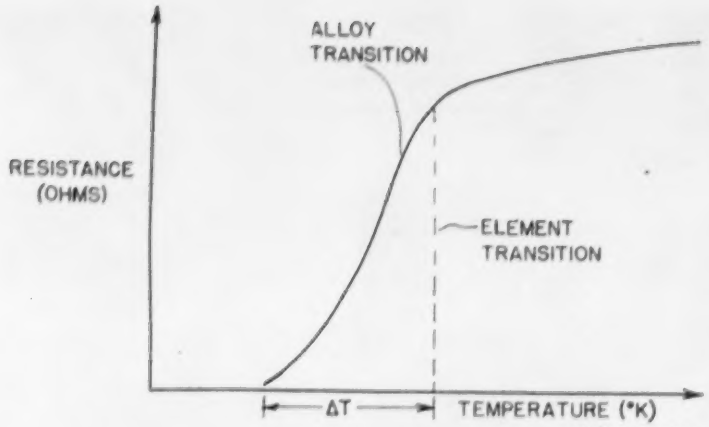


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Figure 3, Alloy and element transition to zero resistance state.

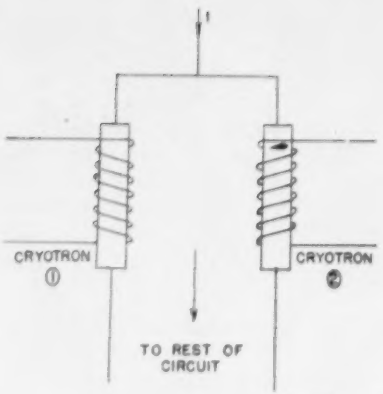

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Figure 2, Small currents control big currents.

mal region the flux rushes back into the wire, and the bridge is again disturbed. This property has some interesting potential applications. Not only will we be able to shield a region electrically by placing it inside a conducting surface, but by making this surface superconducting we can produce magnetic shielding as well.

In the search for superconducting materials many elements and alloys have been found to be superconductive. Alloys of a superconducting element and a non-superconducting element have been found to be superconductive, as well as alloys of two non-superconducting elements. Undoubtedly, as we develop equipment that can produce temperatures closer and closer to absolute zero we will discover still more superconductors. The difference in properties between an element superconductor and an alloy superconductor is that the transition for the element is sharp (a point of discontinuity), while the alloy transitions are more spread out. In other words, there is a region over which part of the alloy is superconductive and part is not.

This state of the alloy is called the intermediate state and has been under extensive investigation in the last several years. The mechanical mixture of the superconductive and non-superconductive phases present in the intermediate state may be observed with the aid of diamagnetic or magnetic powders. Diamagnetic powder will stick to superconductive regions, while magnetic powder is attracted to normal regions (note: only one type of powder need be used in a given test as the powder's appearance can be easily distinguished from that of the material's surface.). By observing the powder distribution on the specimen's surface one can see distinct regions of superconductive and non-superconductive material.

Cryotrons For Computers

Because cryotrons have power gain as well as current gain, they can be interconnected in logical networks as active elements. This, in addition to the fact that they are small, light, and dissipate little power, makes the cryotron ideal for computer applications. It has been estimated that a large-scale digital computer can be made to occupy one cubic foot, exclusive of helium refrigeration and terminal equipment. The power required by such a machine would be approximately one-half watt, again excluding refrigeration and terminal equipment. However, the really big hope for cryotrons is in reliability. It is anticipated that operation in an inert helium atmosphere at a temperature near absolute zero where chemical activity and diffusion processes are essentially stopped, promises a very high degree of reliability.

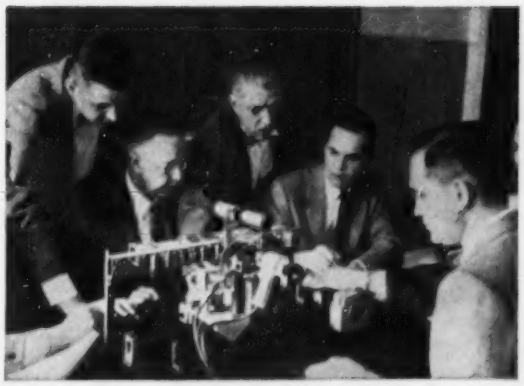
Cryotron's Drawbacks

Present drawbacks on the use of cryotrons are: (1) There is a high frequency limit to the superconductive effect. Materials which are superconductive at lower frequencies do not exhibit a superconductive state at signal frequencies above this limiting frequency. (2) The L/R time constants of today's cryotrons are too high, putting a limit on the frequencies at which cryotron circuits can be operated. (3) As cryotrons get smaller and more delicate (it is hoped to make cryotrons as small if not smaller than transistors) it becomes more difficult to produce them on a commercial basis.

The solution (if there is one) to the first drawback will come as more and more is learned about superconductivity. At present many theories are being projected to explain it, the most successful to date being that of Bardeen and Cooper who place emphasis on the coulomb interaction at very low temperatures. However, superconductivity is definitely still in the pioneer stage and much remains to be done in the coming years.

The L/R drawback is of a more practical nature. Scientists know what has to be done, the question is how to do it. In a practical circuit the L and R will be of different cryotrons, but since identical cryotrons will be involved one can speak of the L/R time constant of a given cryotron as being the fundamental time constant of the circuitry. Circuit speed can be increased by using a hollow center wire (therefore higher resistance in normal state). Superconductivity is a skin effect, penetrating but a few atom layers. Therefore, the center of a wire can be removed and the wire will still have zero resistance in the superconducting state. The core need not actually be removed, provided it has a relatively high resistivity. Wire with a high resistivity core and a superconducting

(Continued on Page 52)



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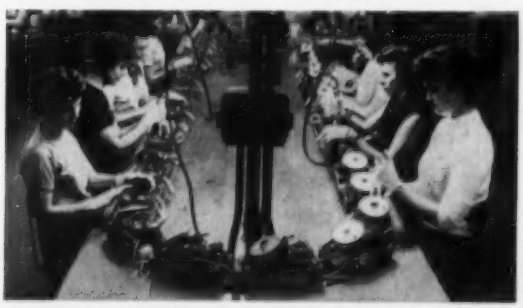

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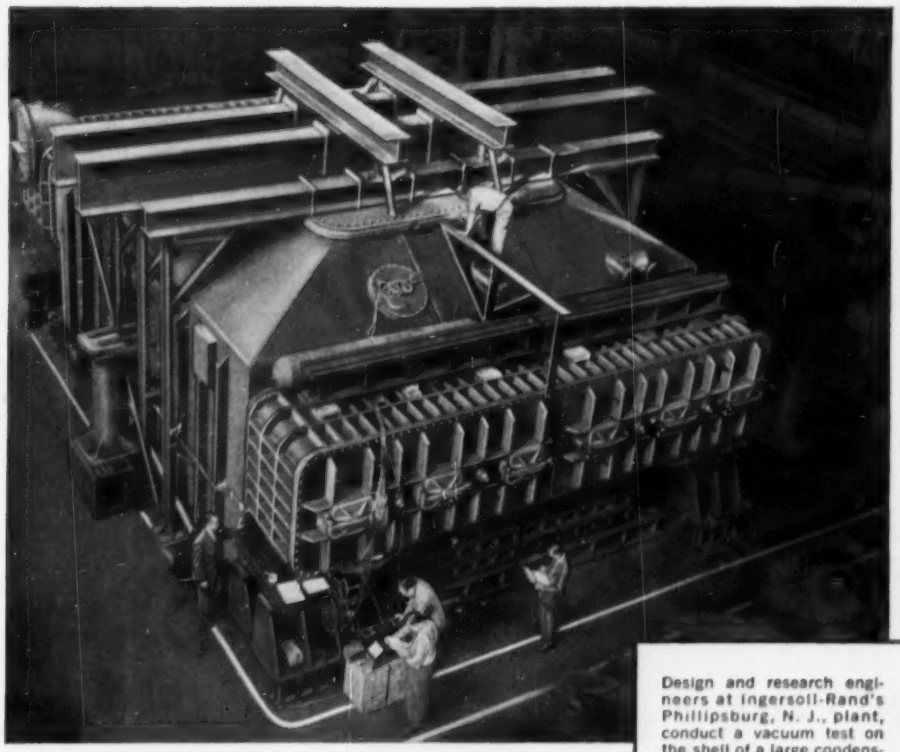

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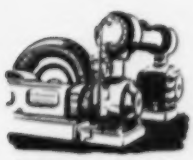

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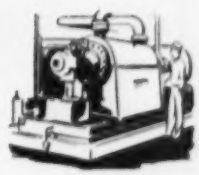

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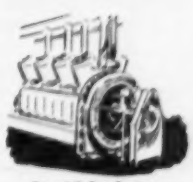

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THE PRESIDENT'S MESSAGE—

HOW TO GET THINGS DONE

In the April issue of "Reader's Digest" appear two articles which seem worthy of some serious thought. One is a condensation of a book by Arnold Bennett first published in 1907, entitled "How to Live on Twenty-four Hours a Day." The other is an article by Keith Funston, the President of the New York Stock Exchange, dealing with advice given him when a youth: "When you know you should do something, do it."

Both articles deal with the effective use of one's time. Both offer suggestions which can hardly help being of benefit to anyone who will follow their advice. Boiled down, both come to the matter of effective planning and determined effort.

All of us, I am sure, have experienced days when we retire with a sense of futility, of nothing accomplished. Each of us has observed the conflict between that part of him which is anxious to achieve and that part which is anxious to shirk. Nearly everyone has noticed the boredom resulting from wasted time. The suggestion is advanced that a certain amount of conscientiousness, determined effort expended in controlling the mind and in keeping it harnessed to a worthwhile vehicle, will bring rewards far greater than might be expected.

It is not suggested that this will be easy, or that the habits of sloth to which most of us are prone, are easily broken. But the point is made that the way to begin is to begin, and that having begun, a certain momentum is achieved which makes each successive step easier. Mr. Bennett makes the very good point that each of us has a full twenty-four hours to dispose of each day, and that it is impossible to waste time in advance. We can employ usefully or we can waste each minute only as it comes to us. The past is gone. Our thought should not be, "Why did we do that?" but "What do we do next?". A little forethought, a little cogitation, a little planning may give the answer.

Mr. Bennett's article concerns itself principally, at least on the surface, with the use of leisure, while Mr. Funston's thesis appears to lie more in the area of working hours. But the advice of both is just as good when applied to any activity, whether intra- or extra-curricular. You have all heard it said that the way to get a thing done is to ask a busy person to do it. If we define a busy person as one who accomplishes more than average a correlation may begin to appear between this commonly-acknowledged view and the advice of Messrs. Bennett and Funston.

Expressing the whole thing in terms you could paste in your hat, we might summarize the rules for accomplishment somewhat as follows:

1. Think ahead
2. Arrange projects in the order of importance
3. Begin
4. Keep at it.

Roscoe H. Fuller

ALUMNI ENGINEERS

Morris D. Farr, ME '26, has been appointed salary administrator in addition to his present duties as assistant director of employee relations for the Pennsylvania Power & Light Co. in Allentown, Pa. In his new capacity he will be responsible for the operation of the company's new salary administration program. His tasks will include review and approval of all salary changes of employees covered by this plan and maintenance of proper salary relationships throughout the company. Mr. Farr joined the power company as a member of its engineering department in 1927. A year later, he was transferred to the general commercial department as a rate engineer and in 1933 was promoted to assistant to the department head of the rate and contract department. Following that he was senior rate engineer, research assistant in the treasury department, and chief research assistant.

Anthony J. DeFino, CE '40, has been elected vice-president of Hupp Corporation. He has been with the company since 1955 after serving as vice-president and general manager of the All-Year Air Conditioning Division of Servel, Inc. He is now a member of the board of directors of the Air Conditioning and Refrigeration Institute after having been president in 1954.

Anthony J. DeFino

Gerhard Sonder, ME '48, is supervisor of compressor design, small aircraft engine department, General Electric Company, and has recently received his second patent award. He is now living in Cambridge, Mass.

Charles W. Egbert, ME '36, has been named manager of applications for York Corp., a subsidiary of Borg-Warner. Egbert joined the corporation in 1936 and has worked up through the organization in various sales and engineering capacities. He is now living in York, Pennsylvania.

Charles W. Egbert

Frederick W. Kuehn, EE '28 was recently promoted to plant betterment engineer at the Hazelton, Pa., plant of the Pennsylvania Power & Light Co. Following graduation from high school, Fred joined the New Jersey Zinc Co. as a laboratory assistant and a year later was awarded the company's August Heckscher Scholarship for study at Cornell. Graduating with the EE degree, he began his electric utility career with the New York Power & Light Corp., Albany, and the following year joined Pennsylvania Power & Light Co. Mr. Kuehn is a member of the Pennsylvania Society of Professional Engineers, the metering committee of the National District Heating Association, and Anthracite-Lehigh Valley section of the American Society of Mechanical Engineers.

H. R. Johnson

H. Richard Johnson, EE '47, has helped organize the Watkins-Johnson Co. to deal in research, development, and manufacture of electron devices. The firm, which expects to locate laboratory and manufacturing facilities in the immediate vicinity of Palo Alto, California, will specialize in microwave tubes. Dick is the vice-president and recently resigned as head of the microwave tube department of Hughes Research Laboratories, Culver City, California.

Mr. Johnson received his PhD in physics at MIT in 1952. At Cornell he was associated with an OSRD project in 1946 and was a teaching assistant in Physics during 1946-1947. His major studies were in the fields of quantum mechanics and electromagnetic theory. He also worked extensively on wave propagation on a helix, microwave absorption spectrum of ketene and on an ammonia beam spectroscope. His research activities contributed to the general knowledge of molecular structure and rotation spectra. Johnson has also been the author or co-author of eighteen publications in technical journals and has six patents applied for. He is a senior member of the Institute of Radio Engineers and of the American Physical Society.

Robert H. Bahney, ME '16, has retired as chief engineer of Republic Steel Corporation steel plants. He was with this concern for his entire business career of forty years.

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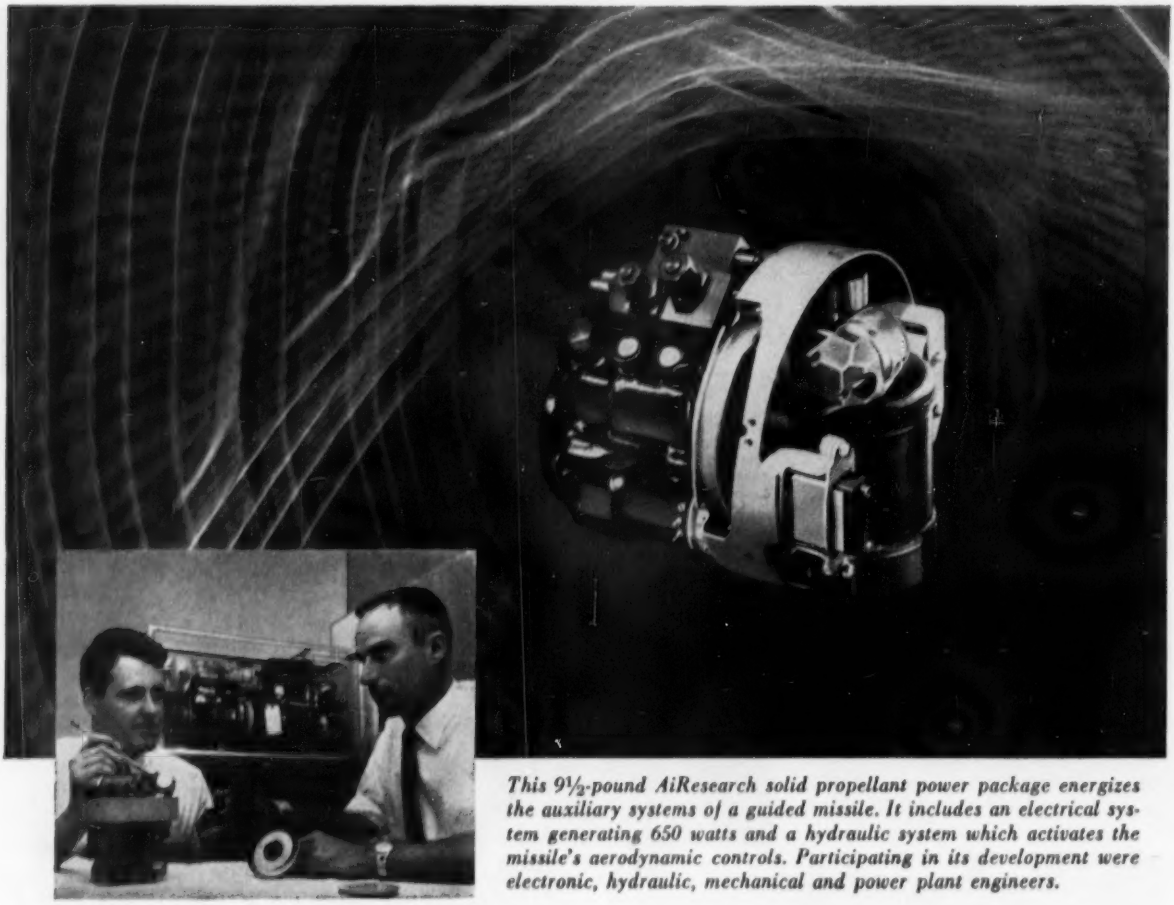

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FIFTY YEARS AGO IN THE ENGINEER

Things are now sizzling in the field of engineering education and all sorts of iconoclastic ideas are being advanced as to what we must do with our engineering courses, and dire predictions of disaster immediately if not sooner are being made, these occurrences to take place unless we adopt some method of training workmen for our industries. This last argument has the hallmark of truth because manufacturers who need skilled labor are finding it increasingly difficult to secure workmen, and a very considerable part of the supply which is secured comes from European countries.—The Sibley Journal of Engineering, *February 1908*.

There is, I believe, no reason under the present general plan of technical education why the first year course for engineering courses could not be made uniform to the great advantage of the university, the student, and the public at large. What is good for the beginner in Civil Engineering is good for the beginner in Mining Engineering and in Mechanical Engineering, and what is good for them is equally good for the embryo-electrical or chemical engineer. They are all a long way from their goal. What they need in the beginning of their course, is a year of arduous study in fundamental science, mathematics, physics, chemistry, drawing, with some English and history, and with a course in surveying and shop work in the summer time.—The Cornell Civil Engineer, *February 1908*.

The new Term has started. As usual, many have dropped by the way, but work goes on just the same. We all have a chance to start fresh and keep our work up to the mark. To the Seniors this word of advice is probably unnecessary, but the Freshmen never seem to realize that all the latter part of the work depends on the first few weeks. They say to themselves that they will rest for a while and make it up later. This is a fatal error, as some have already found out, others need to have it hammered in time and time again. A very low "Prelim" pulls one's average down much more than a good one can possibly raise it. There is a proverb which says that a word from the wise is all that is necessary. In this case the wise do not need the word —they have their work always well in hand. It is the foolish that always have to learn by experience.—The Cornell Civil Engineer, *February, 1908*.

A smoking room in Lincoln Hall is now an assured fact. Dean Haskell has very kindly given the Association permission to use the room in the basement under his office. It is large and light and is in every way desirable for that purpose. Tables will be put in the room and the magazines will be brought down from the museum. This will fill a long felt want, as there has been something needed to bring the students closer together and to give a place for those not working to talk without disturbing the men at work in the Library. A committee has been appointed by the president of the Association to take charge of the finances of the smoking room, and the Senior memorial. It is expected that almost $150 will be spent in fixing the room up. Everyone in the college will be asked for fifty cents, and the Seniors for an additional fifty for the memorial. The money collected for the memorial will be spent for pictures or decorations for the smoking room. Please make the work as easy as possible for the committee, and when they come around do not put them off. It is for a good cause, as everyone knows, who has tried to get a few puffs between recitations on a cold day. —The Cornell Civil Engineer, *March 1908*.

Professor Anthony planned during the years 1884-86 an elaborate and complete equipment for absolute measurements in electricity and magnetism. For this purpose an isolated building, in the construction of which iron was scrupulously avoided, was erected to the west of the then existing buildings of Sibley College. In this structure, which was popularly known as the "copper house" the instruments were mounted; among others a tangent galvanometer for the measurement of heavy currents which far exceeded in size and accuracy of construction anything attempted before or since. This plant, although admirably designed for its purpose, was unfortunately very short lived. The rapid growth of Sibley College compelled the construction of buildings containing large amounts of iron and of moving machinery in the immediate vicinity of the copper house whereby the constancy of the magnetic field upon which it entirely depended was greatly interfered with. The extension of the electric railway across the campus completed the demoralization of the earth's magnetic forces and compelled the abandonment altogether of an equipment upon which several thousand dollars and several years of time had been expended.—The Sibley Journal of Engineering, *April 1908*.

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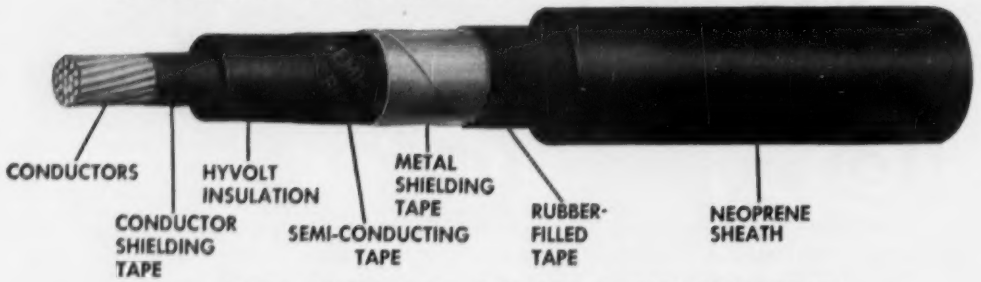

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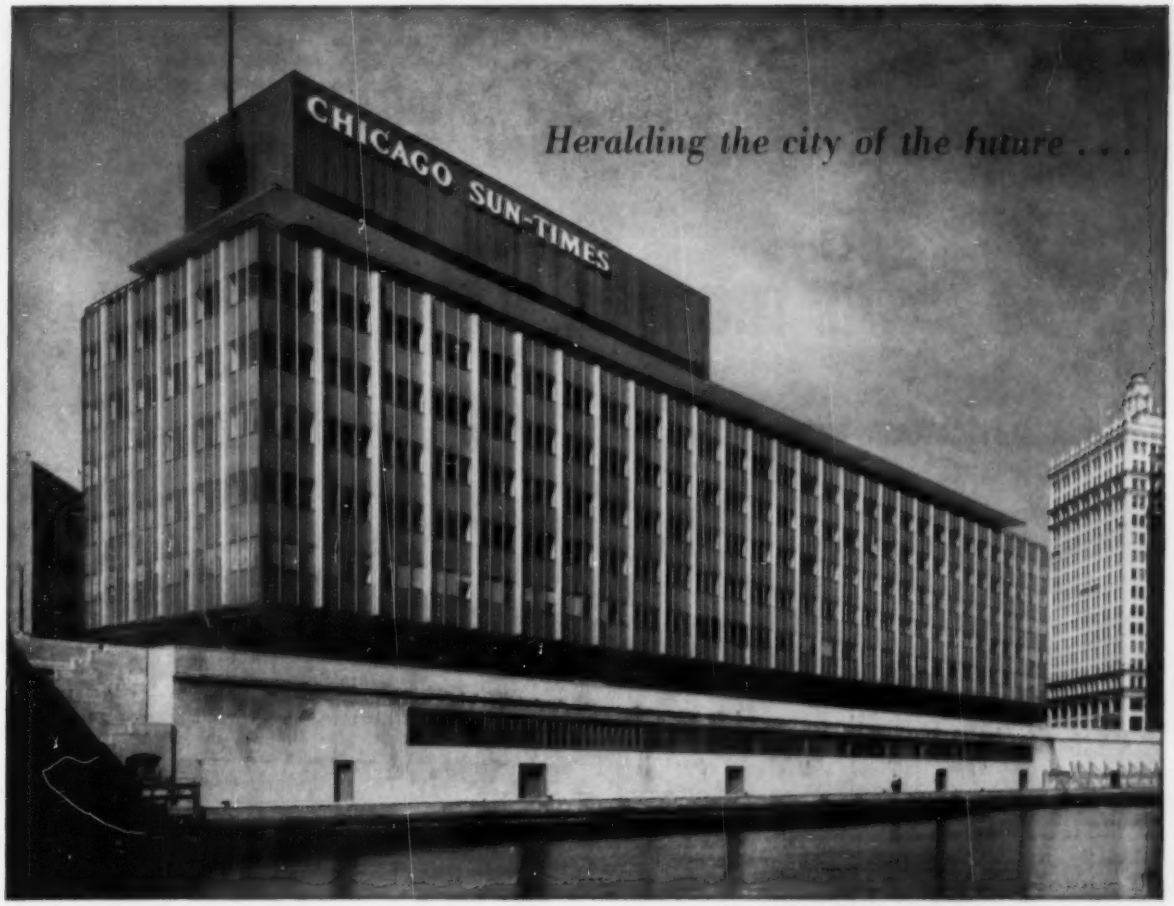

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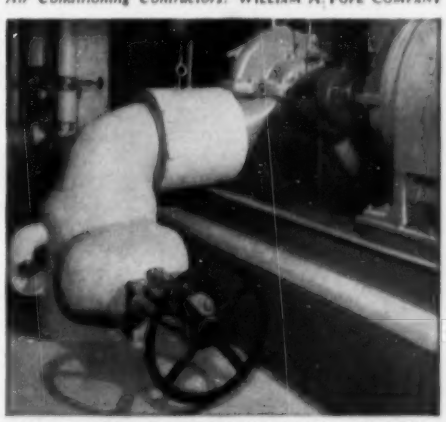

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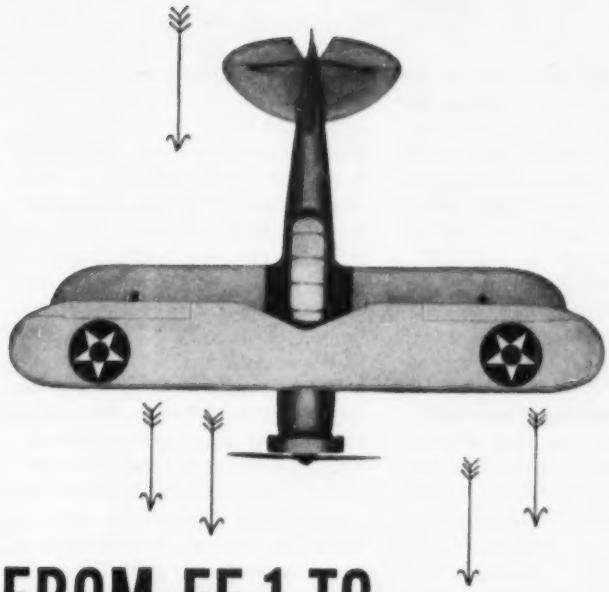

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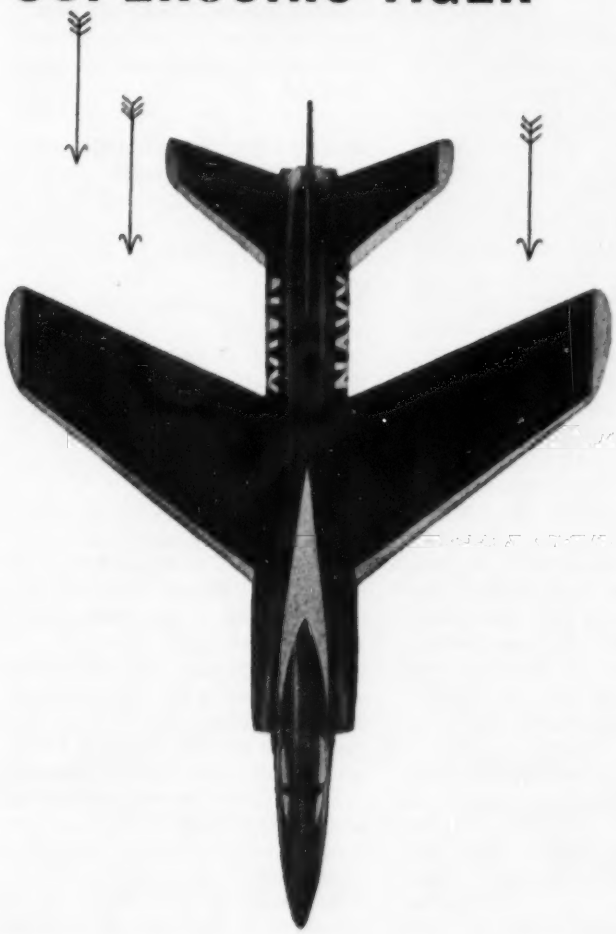

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COLLEGE NEWS

WIEGANDT GETS GRANT TO STUDY SEA WATER CONVERSION

Man may soon be able to tap the resources of the seven seas for fresh water as a result of research being carried on at Cornell University's School of Chemical and Metallurgical Engineering.

Herbert F. Wiegandt, chemical engineering professor at the School, has received a grant of $15,000 from the U.S. Department of the Interior for a process study into a method of converting sea water. Professor Wiegandt has been conducting experiments on the method, which is based upon crystal purification, since 1953.

The process involves freezing. "It is a 'bootstrap' operation," Professor Wiegandt reports, "in which, with a little help from a heat pump, the melting of pure ice is used as a means of refrigeration for generating ice in sea water. Purification is accomplished in a water-ice tower employing reflux."

Professor Wiegandt adds, "The study is intended to lead to engineering developments which will result in low-cost conversion of sea water.

"There are," he adds, "heavily populated dry areas all over the world which would receive direct economic benefits from a practical, inexpensive method for converting sea water."

The United States, which is facing a growing water supply problem, will also benefit from the research. A large-scale multi-effect distillation unit using sea water has recently gone into operation in California to provide water for a major power-plant.

BOMBER RESEARCH AT CORNELL AERONAUTICAL LAB

Modern bomber aircraft travel at such high speeds that their bombing accuracy can be seriously impaired.

Scientists have found that bombs dropped from high speed aircraft are thrown off their normal trajectory by turbulent air flowing past the airplane. This turbulence can cause a bomb to pitch, yaw, spin or tumble end over end. On one occasion a bomb was flipped back into the airplane bomb bay after it had been released.

Such bomb drop behavior not only endangers the aircraft and its crew but also makes bombing accuracy extremely difficult to achieve.

Cornell Aeronautical Laboratory, Inc., of Buffalo, N.Y., has studied bomb separation problems for the Air Force. In the current issue of "Research Trends," a publication of the Laboratory, engineer Wilbert Schwartzapfel discusses the unique testing technique developed by CAL for its bomb drop program.

When a bomb is dropped from a high speed airplane, the critical portion of its trajectory lies within the region of turbulent air close to the aircraft. It is simple to predict a bomb's trajectory once it has entered the relatively calm air further below the airplane. Data is needed, however, on the behavior of a bomb as it falls through the disturbed air near the bomber.

Cornell Aeronautical Laboratory has developed special techniques using its 1,000 mile an hour wind tunnel to simulate bombs falling through the turbulent air region.

When the program began at CAL in 1952, scale model bombs were released from a model of the B47 medium bomber which was mounted in the wind tunnel. As the bombs fell through the tunnel's high speed air stream their trajectories were recorded by cameras. The bomb drop data, derived from these wind tunnel tests, were compared with actual B47 bomb drops. The results proved that the CAL tunnel technique had successfully simulated actual bomb drop performance.

Bomb drop simulation in a wind tunnel cuts the time needed to place bomber aircraft on an operational basis. Previously, long delays developed while actual bomb drop tests were conducted with the new aircraft itself. Using its wind tunnel technique, the Laboratory is able to forecast the bomb drop characteristics of a new bomber even before it is built.

There are other advantages to wind tunnel bomb drop studies. The tunnel technique eliminates the necessity of exposing personnel and valuable aircraft to the hazards of actual bomb drop testing. In addition, a large number of tests can be performed quickly in a wind tunnel at relatively low cost.

CAL has used its wind tunnel technique to simulate bomb drops from the internal bomb bays of large bomber aircraft and from the wing racks of smaller fighter-bomber aircraft. Successful tests have been performed at wind velocities up to the speed of sound.

The Laboratory currently is studying the bomb drop characteristics of more advanced aircraft which travel well beyond the speed of sound.

NEW CABLE RESEARCH AND TEST CENTER TO BE BUILT

A high voltage cable test station will be set up out by the airport by the fall of 1959. This fact was made known at a meeting of the Cable Engineering Section of the Association of Edison Illuminating Companies held on March 10, 1958 in Phillips Hall. The purpose of the test station is to work on 345 kilovolt cables under conditions which will closely approximate their eventual use commercially.

In his introductory remarks, Mr. L. I. Komives explained that cables of this type will probably be needed within ten or fifteen years in places where overhead transmission lines are unfeasible such as cities. There are in use today overhead lines which can carry this high voltage, however present cables are only capable of carrying voltages which are a small fraction of the amount.

Many large power companies and cable manufacturers have pooled their resources in a Steering Committee set up under the AEIC. This committee will direct the activities of the project in which Cor-

nell has become a third partner. Cornell will carry on most of the testing and direct the research after the station is set up.

Four speakers followed Mr. Komives' introduction. They each explained briefly a different phase of the problems which are faced and any progress or research which has been carried out toward solving them up until now.

Dr. Wiseman from Okonite discussed "Insulation" which is the prime problem facing the development of a high voltage cable. In relation to this, he talked about the need for heat dissipation and a very low and constant power factor which is needed in the cable.

Dr. Merrell, of Phelps, Dodge, spoke on "Soil Thermal Resistivity." He stated that the two factors which have been found to influence the resistivity are the density and the moisture content and that these conditions vary quite considerably and are extremely hard to duplicate for testing purposes.

Mr. Eich from Anaconda talked about "Research Techniques in Oil and Paper" which are two common types of dielectrics. He explained that there are essentially four variables involved when employing paper and oil dielectrics: temperature, voltage, chemical interaction, and hydraulic transients. In tests made thus far and in the future, they use statistical methods to evaluate the data.

Mr. Meyerhoff of the General Cable Company concluded the meeting with a talk on "Power Factor Measurements." He stated that the problems involved included high current, high voltage, and a sensitivity of plus and minus .005%; a combination of conditions which until now have never been achieved.

DR. VAN DER POL APPOINTED VICTOR EMANUEL PROFESSOR

Balthasar van der Pol, director of the International Radio Advisory Committee in Geneva, Switzerland, and an authority on mathematics, engineering and biology, is the holder of the Victor Emanuel Professorship at Cornell University for the spring term.

The range of Dr. van der Pol's interests is unusually wide. He was born in Holland in 1889 and received his education there. He gained international prominence for his discovery of relaxation oscillations—the "van der Pol oscillator" is a household word among engineers and physicists.

Dr. van der Pol has also made significant contributions to the field of pure mathematics, particularly in number theory. He is co-author of a book on operational calculus which has become a classic in the field.

He was co-founder and has been president of the Netherlands Radio Society, and has served as a delegate to a number of important conferences in the field of international telegraphy.

He is a member of the Royal Dutch Academy and a foreign member of the French Academy. An accomplished violinist and pianist, Dr. van der Pol has also published articles on the theory of music.

Peter Gaalaas

Dr. van der Pol

PROF. C. W. MASON RECEIVES NEWLY ESTABLISHED CHAIR

Deane W. Malott, president of Cornell University, recently announced the appointment of Prof. Clyde W. Mason of the University's School of Chemical and Metallurgical Engineering, to fill a newly established chair made possible by the bequest of the late Prof. Emile M. Chamot.

Professor Mason, who collaborated with Professor Chamot in the writing of a two-volume "Handbook of Chemical Microscopy," is an authority in the field of chemical microscopy, the branch of chemistry which deals with the applications of the microscope in technology and research. He is also a specialist in metallography, the study of the structure and composition of metals, a field in which Professor Chamot gave the first courses at Cornell.

Emile Monnin Chamot, donor of the bequest which makes the new chair possible, was born in Buffalo in 1868 and died at the age of 82 in 1950. He was a member of Cornell Class of '91, and Professor of Chemistry at the University for more than forty-five years. He was world-famous for his work on water purification and a pioneer and the foremost exponent of chemical microscopy.

Professor Chamot came to Cornell in 1890 as an assistant in chemistry. He received the B.S. degree in 1891 and the Ph.D. in 1897. In the same year, he married the late Cora Genung, a talented musician and member of a prominent local family. In 1901, after studying in France, Germany and Holland, Professor Chamot was promoted to assistant professor. In 1910 he became Professor of Sanitary Chemistry and Chemical Microscopy.

In 1935, he was relieved of his teaching duties and engaged in research on water purification and microscope analyses, pursuing this work even after his retirement in 1938. Thereafter, he engaged in research both at the Baker Laboratory on the Cornell University campus, and in his home, where he had installed research equipment.

In addition to the handbook which he wrote with Professor Mason, Professor Chamot was the author, with Dr. H. W. Redfield, Cornell '00, of "Analysis of Water for Household and Municipal Purposes." He was also the author of "Elementary Chemical Microscopy."

During World War I, Professor Chamot served as consultant to the U.S. Ordnance Department on ammunition, directing a research program at Cornell. He was also a consultant on explosives for the National Defense Research Committee project at Cornell during World War II.

For a number of years, Professor Chamot served as advisory chemist to the Ithaca Water Department. Before the typhoid epidemic of 1902-03, he had warned that the water in Six Mile Creek was unsafe, and after the epidemic he

(Continued on Page 52)

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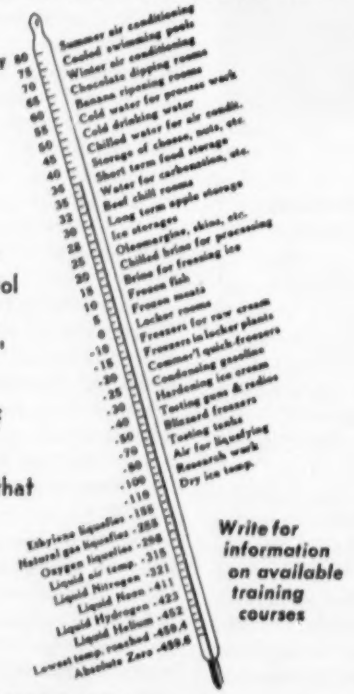

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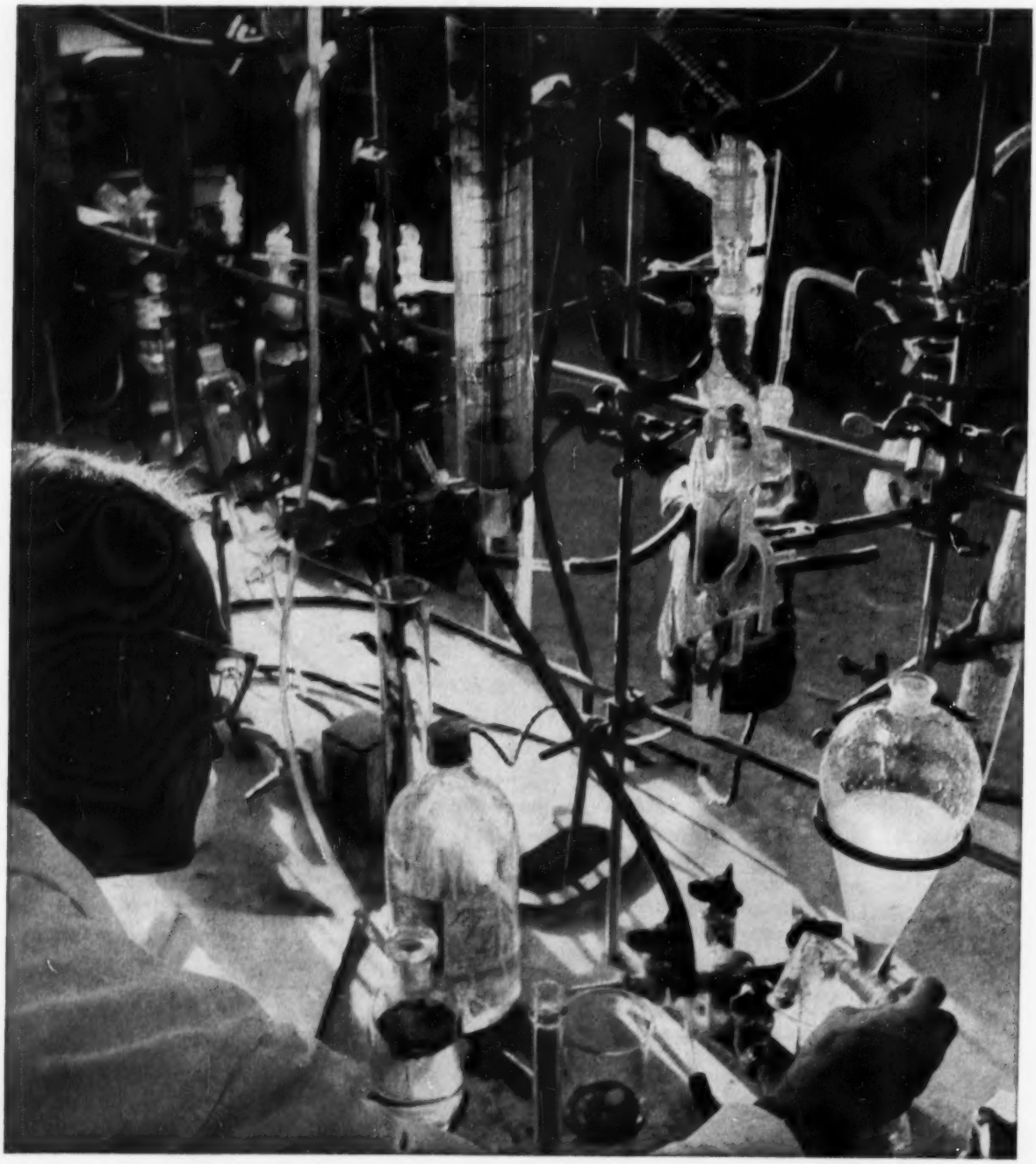


Research at Cornell—

PROFESSOR RYDBECK STUDIES SOLAR EMISSIONS

Research on the basic nature of radio emissions from the sun is one of the studies being carried on at Cornell University by the well known Swedish scientist, Professor Olaf E. H. Rydbeck.

While the research is basic and intended to give man a better understanding of solar electric phenomena, Professor Rydbeck also hopes that there will be immediate, practical applications in the field of radio engineering.

Dr. Rydbeck, who has been Victor Emmanuel visiting professor at Cornell, is developing a theory on the interaction between electromagnetic waves and electron plasmas in ionized heterogeneous media, with application to the outburst of radio-noise waves from the solar corona and the generation of audio-frequency dawn chorus noise in the atmosphere. "The theory is useful in studying certain microwave tube phenomena," explains Professor Rydbeck, which is another example showing that basic research in science can yield unexpected technical applications.

"Radio emissions from the sun are sometimes tremendous," says the professor, "and sometimes correspond to black body radio radiation of billions of degrees from the sun spots. The disturbances on the sun's surface result in an extremely large output of radio noise, which is so ably recorded here at Cornell."

"We hope to be able to explain how energy from the electronic stream in the solar system is transformed into violently strong radio waves that we receive on earth, as a result of the research being done here."

Scientists have noted that often a greater intensity of these radio-wave impulses are recorded on earth following explosions on the sun, and that magnetic storms occur shortly after. It is hoped, by Professor Rydbeck, that some day the true relationship between the two may be established.

These magnetic storms sometimes play havoc with electric and electronic communications. Radio messages may almost go to wrong destinations, or simply not go anywhere. The effects of these magnetic storms are particularly severe in more northern regions.

In Professor Rydbeck's native Sweden, manual signals are substituted for electrically-powered signals on the railroads, for instance, during severe magnetic storms. "Men with flags go out and transmit control signals," he explains. "If we relied on the electrical system of signals, and they failed to function or did so improperly, then serious accidents might occur. Part of Sweden, you know, is very far north, in the Arctic Circle, and the effect of the magnetic storms, which manifests itself in electric earth currents following the rails and the signal cables, is greater there than in areas more distant from the polar regions.

"If we are able to establish the true relationship between these radio signals from the sun and magnetic storms on earth, then it may be that we will get a really efficient 24 hours warning of their approach. We are receiving the radio impulses about a full day ahead of the storms, but we want to be sure that they are accurate in foretelling the storms. Work remains to be done in this field, but we are hopeful that eventually we will be able to understand the relationship between the radio noises from the sun, and the corpuscular, electric showers which cause magnetic storms."

"When there is an explosion on the sun, particles are emitted, which pass through the sun's corona. The corona, which corresponds to the earth's ionosphere, is composed of electrons and ions, and it is believed that the emission of particles from the sun through this coronal ionosphere causes the radio waves picked up on the earth. It is likely that violent solar particles of this type, of opposite electrical charge, move through space and, when coming some earth radii distance from the earth, split up and form a gigantic extra-terrestrial current ring, mainly in our equatorial plane, from which charged particles spiral down along the earthly magnetic lines of force to produce the aurora as they impinge upon, and electrify the polar ionosphere."

Professor Rydbeck has been engaged in this study since his arrival at Cornell last September to become Victor Emanuel Visiting Professor of Engineering. A Swedish scholar and engineer, he is professor of electron physics in the Chalmers University of Technology, Gottenburg, and Director of its Research Laboratory of Electronics with Radio Wave and Radio Astronomy Observatories at Onsala, and, up to recently, at Kiruna north of the Arctic Circle.

He is a member of the Royal Swedish Academy of Sciences, which awards the Nobel prizes in physics and chemistry. He is a graduate of the Royal Technical University in Stockholm. From 1938-40 he was Gordon McKay Fellow at Harvard University, where he received a doctorate in science in 1940.

There's a Metal Problem in your future that Inco can help you solve

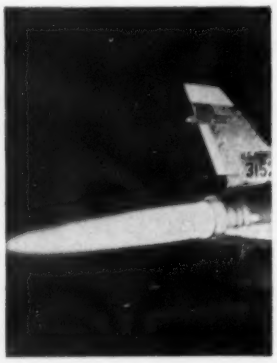
In the meantime, see if you can tell which Inco Nickel Alloy proved to be the answer to these problems.

Number the picture captions!

1. **"S" Monel** hard-grade nickel-copper cast alloy
2. **Inco Nickel**
3. **"K" Monel** age-hardenable nickel-copper alloy
4. **Inconel** nickel-chromium alloy
5. **Monel** nickel-copper alloy
6. **Inconel "X"** age-hardenable nickel-chromium alloy
7. **Monel "403"** non-magnetic nickel-copper alloy

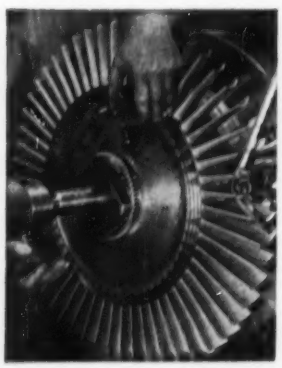
See answers below

☐ **Oil well drill collar** — Needed: non-magnetic metal with high strength. Which Inco Nickel Alloy . . . ?

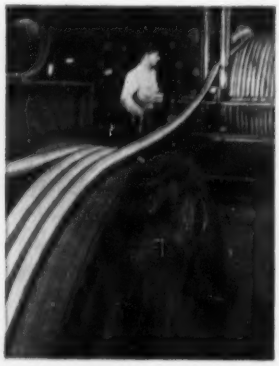


☐ **Jet engine flame tube**—Needed: oxidation and corrosion resistance at jet engine temperatures. Which Inco Nickel Alloy . . . ?

☐ **Radar platform "leggings"** — Needed: resistance to abrasion and marine corrosion. Which Inco Nickel Alloy . . . ?

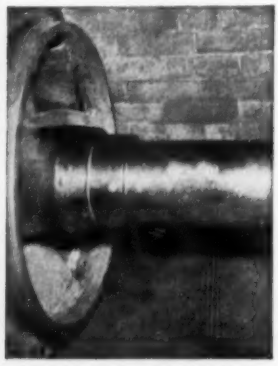


☐ **Gas turbine blades** — Needed: hot strength up to 1500°F., low coefficient of expansion. Which Inco Nickel Alloy . . . ?



☐ **Submarine cable sheathing** — Needed: non-magnetic metal resistant to marine corrosion. Which Inco Nickel Alloy . . . ?

☐ **Ultrasonic drill** — Needed: high magnetostrictive ability to produce ultrasonic vibrations. Which Inco Nickel Alloy . . . ?



☐ **Shaft sleeve for salt water pump** — Needed: extra-hard casting alloy that resists corrosion. Which one . . . ?

You may have to take this kind of quiz *again*. You may be designing a machine which requires a metal that resists corrosion . . . or wear . . . or high temperatures. Or one that meets some destructive *combination* of conditions.

When you start to design equipment, you will have to select the proper material to meet given service conditions. Over the years, Inco Development and Research has successfully solved many metal problems, and has compiled a wealth of information to help you.

For more on special problems solved with Inco Alloys, send for "Standard Alloys." Write The International Nickel Company, Inc., Dept. 00, New York 5, N. Y.

The International Nickel Company, Inc.
New York 5, N. Y.

Oil well drill collar: 3. "K" Monel; Jet Engine flame tube: 4. Inconel; Radar platform "leggings": 5. Monel; Gas turbine blades: 6. Inconel "X"; Submarine cable sheathing: 7. Monel "403"; Ultrasonic drill: 2. Inco Nickel; Pump's shaft sleeve: 1. "S" Monel

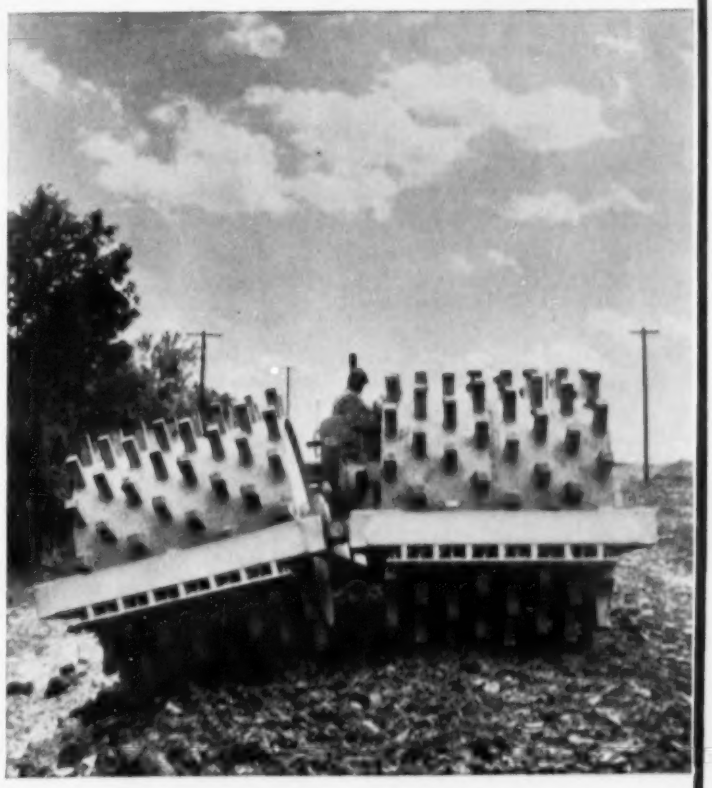
Inco Nickel

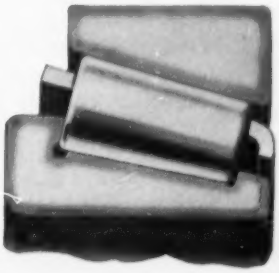
makes metals perform better longer

Tear out this page for **YOUR BEARING NOTEBOOK...**

How to take 22½ ton impacts on drum axle

The designers who built this giant tamping roller had to contend with impacts as high as 1450 psi on the drum axle. To take these terrific loads, designers mounted the drum axle on Timken® tapered roller bearings. Timken bearings are case-carburized to produce hard, wear-resistant surfaces over tough, shock-resistant cores. Their full-line contact between rollers and races gives them extra load-carrying capacity. And because they practically eliminate friction, they help heavy construction machinery start and roll more easily.





Slice a Timken bearing in half and see why it takes shocks

The picture at left shows what you'd see if you cut through a Timken bearing: hard, wear-resistant surfaces and tough, shock-resistant cores.

Want to learn more about job opportunities? Timken bearings help make better machines—machines that enrich our lives. It's what the Timken Company calls Better-ness. If you'd like a career helping to create the machines that create Better-ness, write for: "BETTER-ness and your career at the Timken Company". The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN

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TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ⊕ AND THRUST →⊕← LOADS OR ANY COMBINATION ✳

TECHNIBRIEFS

INDUSTRIAL FACILITY BUILT FROM STEEL GEODESIC DOME

An all-steel "Union Dome"—the world's largest circular building without internal supports—is under construction in Baton Rouge, La., by Union Tank Car Company.

The new building is believed to be the first major industrial use of a dome structure in this country. It will house regional maintenance and tank car repair facilities.

Dimensions of the "Union Dome" are 375 feet across its interior base —greater than the length of a football field—and 116 feet high at the center. Total floor area enclosed by the dome is 110,000 square feet. It is a clear-span dome, containing no internal supports whatsoever. It is also the first geodesic dome to be made entirely of steel.

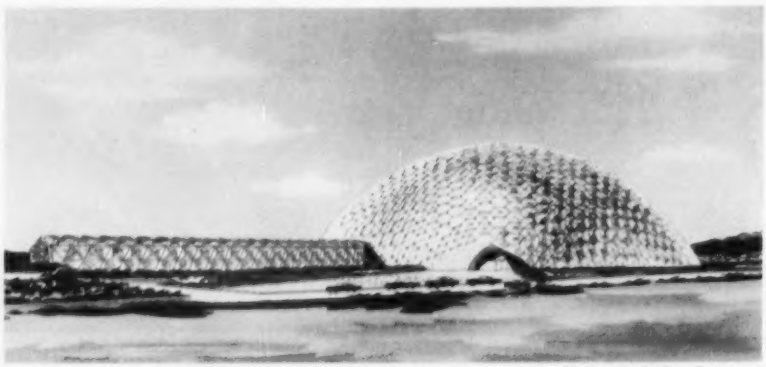
Several major advantages of a clear-span structure such as the "Union Dome" for industrial use include economy in the cost per square foot of area covered, visual control of all working areas from one central point, and unimpeded materials and work flow.

Designs for the "Union Dome" are based on patents for a geodesic dome held by R. Buckminster Fuller and were developed by his firm, Synergetics, Inc., of Raleigh, N.C.

The dome and the facilities which it will house will cost in excess of $1,000,000 (but significantly less than the conventional car repair plant of this size.

The "Union Dome" will consist solely of 320 steel panels fabricated in 12 basic sizes and welded together. The panels were specially fabricated, from standard ¼ inch steel sheet and 4 inch tubing, on location at Baton Rouge.

A tunnel-shaped paint building made of similar steel panels connects with the main circular repair shop area. The paint building is 200 feet long and 20 feet high.



Union Tank Car Company

The all-steel "Union Dome"—the world's largest circular building without internal supports—which is being built in Baton Rouge, Louisiana.

STEEL FRAMES ALLEVIATE WALL CRACKING PROBLEMS

Rigidity, permanence and elimination of wall cracking due to settling are characteristic of the rigid steel frame for structures, both residential and commercial. Any frame, however, is at the mercy of its foundations, so Paul F. Watson, Secretary-Treasurer of the Watson Foundation Company, Inc., of Fort Worth, Texas, conceived an innovation in home foundations. He decided to set base members of the welded frame for his new 2400 square foot residence on 42 cylindrical concrete caissons or piers.

These piers are sheathed in "Sonatubes", a non-metallic lining material which prevents bonding to adjacent earth, and extend down 9 feet to bedrock. Being well below the water table and firmly supported, any movement of the subsoil due to freezing, thawing, changing moisture content, etc., cannot disturb the foundation piers or the surmounting house frame. The frame base, with outer members fabricated from longitudinal angles and diagonal bracing angles are welded together, along with the central I-beam joists, is held to the piers by lag bolts set into the concrete on the top surface.

The principle is new to residence construction, but actually is a modification of the system employed for many skyscraper foundations. Masonry walls of the house, as well as a large fireplace, are supported on a steel apron welded to the lower base angle of the frame, thereby keeping the entire structure above ground level.

ARMY DEVELOPS NEW MINE DESTROYER

The Army has announced the development of a tank mounted, mine exploding roller which will help to keep armored units on the move in any future conflict, despite the tank's most powerful enemy, the buried land mine.

Capable of withstanding antitank mine explosions, the roller clears pressure activated mines before the tank tracks reach the danger point. This makes possible more efficient utilization of tanks by eliminating time consuming search for and removal of mines. The roller was developed by the U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia.

Fabricated of high strength steel, the complete roller is made up of a series of wheels four feet in diameter and six inches thick mounted on independent shafts of axles. The tank in combat pushes a six wheel section in front of each track. The weight of the roller is sufficient to explode any buried mines equipped with pressure activated fuses that may be in its path.

The outer circumference of the roller wheels incorporates a special design which eliminates blank spots in ground coverage. Individual roller wheels are articulated to assist in more even ground pressure and to help absorb the shock of exploding mines.

COMPUTING DEVICE COUNTS TIME OF FLIGHT OF NEUTRONS

Two General Electric engineers at the Knolls Atomic Power Laboratory here have developed a new electronic computing device for measuring, counting and classifying time of flight of neutrons from a nuclear reactor which accomplishes in an hour what it previously would have taken a man a month to do.

Elmer J. Wade and Donald S. Davidson developed the first all-transistorized time of flight analyzer for use in determining the neutron energy distribution of various types of reactors. It contains 256 channels, compared to a device previously in use which furnished only 11 channels for recording information on different energy range neutrons.

Employed in reactor development work, the analyzer, through its work-saving features, has freed highly trained scientists from routine calculating work. They can now spend time saved in evaluating information the new analyzer provides for them.

Savings in time and labor by the new analyzer are matched by the space it conserves at the laboratory, operated for the Atomic Energy Commission. The device is only 8 inches high, 19 inches long and 13 inches deep, compared to earlier analyzer equipment which took up at least 10 times that amount of space at the laboratory.

Most of the space-saving came in use of transistors in place of as many vacuum tubes, along with more compact circuitry through use of printed circuits, Wade and Davidson point out.

In addition, the new analyzer uses only eight watts of power, compared to two kilowatts needed to operate the earlier vacuum tube equipped analyzer.

The engineers said the analyzer works this way:

Development of new reactors at KAPL involves mock-up of various fuel arrangements and accurate measurement of resulting neutron energy spectrum.

This is accomplished in a large part by measuring the time of flight of neutrons over a given distance and recording the number of these neutrons which fall into 256 different velocity ranges. Through various calculations, scientists can convert the velocity of these neutrons into corresponding energy ranges.

To accumulate this vital information, a neutron beam coming out of the thermal test reactor is chopped by a rotating shutter so that velocity can be measured. At the end of a flight path of established length, the neutrons are detected by a counter and the information relayed to the analyzer.

Information on each neutron counted is directed into one of 256 channels, each representing a velocity range. Up to 65,536 neutron counts is stored in each of these channels.

After the experiment this information is transmitted over cables to electronic calculating equipment which punches information from each channel of the analyzer onto a separate card.

This information is then fed into a digital computer for analysis of the data from the cards and the result is then automatically plotted on a graph which shows the reactor energy characteristics.

The entire operation from neutron count to production of a graph which reveals the energy spectra of the reactor requires only about an hour, compared to what would have been a month's work for a single scientist recording data manually.

ELECTRONIC TECHNIQUES AID IN ARCTIC CONQUEST

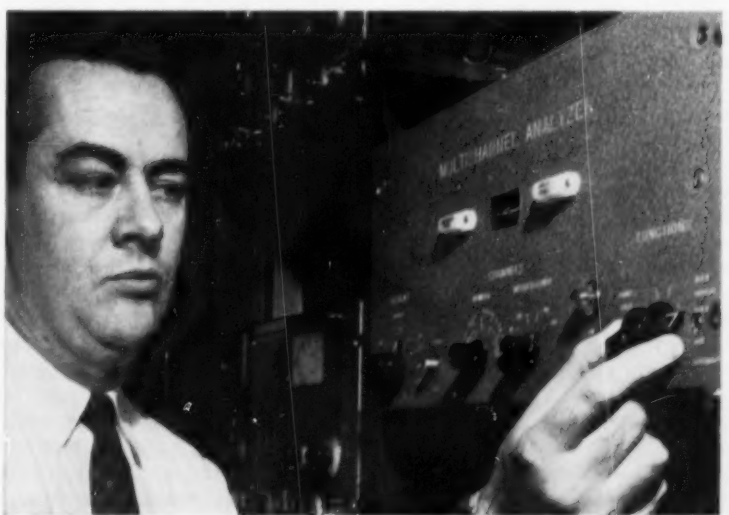
Electronic techniques for marking safe trails in the arctic have been developed by the Army's Engineer Research and Development Laboratories, Fort Belvoir, Virginia.

A system consisting of two parallel wires and a vehicular-mounted radio-type receiver has been successfully tested on the Greenland Ice Cap.

An alternating current is fed into the wires, which are buried beneath the snow on either side of the trail, to electrically mark the route. The receiver on a tracked vehicle commonly known as the "Weasel" detects the current in the wires.

Indicators in the vehicle give the driver his position within the trail. Warning devices alarm the driver when the vehicle gets out of bounds and crosses a trail wire.

Poor visibility during the Polar night, snow storms and summer "white outs" (dense arctic fog) make free movement over the ice cap virtually impossible. Travelers face the possibility of getting lost and falling into hidden crevasses. Bridged over slightly with snow, crevasses are dangerous even in good visibility. With weak wind-built snow bridges concealing the chasm in the ice beneath, they act as pitfalls often wide and deep enough to swallow men and equipment. Safe trails through these



General Electric Company

The first all-transistorized neutron time of flight analyzer is only one tenth the size of previous models. This device which determines the neutron energy distribution for nuclear reactors requires only four-thousandths of the power of other analyzers.

areas are crooked and narrow and visual markers like flags and poles are obscured by poor visibility or destroyed by the elements.

The development of electronic techniques mark a giant stride forward in overcoming these hazards. According to Lynn A. Smitherman, ERDL project engineer, the electronic trail is now being extended over a hundred miles on the ice cap.

Work is continuing to improve existing techniques and equipment. An improved design is already under test over an extended trail on the ice cap. A simplified one-wire trail-marking system which may reduce installation and maintenance costs is also under consideration.

Extensive field tests are being made of various other models of these completely transistorized assemblies on the Potomac Edison lines which will include assemblies for voice communications and phase comparison relaying.

HEAT OF SUN DUPLICATED WITH MOVIE MIRRORS

Through the use of ordinary motion picture equipment, temperatures approaching those on the surface of the sun have been developed. The principle of this generation of heat is a very simple one, comparable to the use of a magnifying glass to set a piece of paper on fire. Highly polished curved mirrors concentrate rays from a carbon arc into a small but very high energy beam that produces temperatures above 7,000 degrees F. The arc image furnace uses two elliptical mirrors, similar to those in motion picture equipment. One directs the energy of the arc at the other, which in turn concentrates the radiation on the specimen being heated. The new device is comparable to a solar furnace with a 60-inch diameter reflector. The solar furnace depends on the sun's rays for energy and can be operated only under favorable climatic conditions. The arc image furnace has a distinct advantage in being compact, portable and operational anywhere at any time. It is composed of arc carbons less than one-half inch in diameter and draws a current of 200 amperes (twice that of a normal home). A shutter can be so placed to cut the beam. A tilted mirror can also be added which allows the beam to be tipped at any given angle to melt a specimen. The most interesting feature of the beam is that it can be projected through a transparent window into an enclosed vessel that is at a controlled atmosphere.

TWENTY-ONE MILLION WATT RADAR SIGNAL TRANSMITTED

Successful transmission of powerful microwave or radar-like signals by Cornell Aeronautical Laboratory, Inc., here, was labeled by the Army today as significant to the future development of ICBM detection apparatus. Radar-like signals at a peak power of 21 million watts —many times more powerful than believed possible—have been transmitted by the Laboratory, the Army reported.

The powerful signals, believed to be the largest peak power ever radiated, were transmitted by a special microwave generator.

An ICBM, because of its extreme speed and unusual configuration, is difficult to detect with present day radar equipment. Any radar which is contemplated for use against missiles must have a great deal more power than a corresponding radar used in detection of aircraft.

Therefore, "Any development increasing the peak power which can be emitted by a radar is viewed as significant in the development of future detection equipment," the Army stated.

NEW MISSILE BASE "ONE STEP" BEYOND PUSH-BUTTON WARFARE

"This goes one step beyond push-button warfare, for at the Talos Defense Unit you don't even need to push a button to send this weapon into action."

That was the description given October 15 by Dr. Elmer W. Engstrom of the Radio Corporation of America with regard to the Talos Defense Unit, the first completely automatic system for firing and guiding missiles to their targets. The base is an electronic control center which can go into action by itself in response to warning signals from remote outposts.

"A decade ago," Dr. Engstrom said in a brief speech preceding the presentation, "it would have seemed like a figment of science fiction to speak of a base that could fire a missile and guide it to its target without the help of a human hand. But here it is, before you, today."

The Talos Defense Unit (TDU) is composed of three structures—one a long, low concrete and steel building (316 × 80 feet horizontally, 30 feet tall) containing the control center, and the other two circular magazines with the launchers, resembling anti-aircraft guns, in the center and numerous cells on the perimeter to house the missiles themselves. All three are built to withstand the pressures of the missile take-off and near misses from enemy bombs, and all are air-filtered for protection of the equipment and personnel.

SINGLE-STAGE PURIFICATION BY FRACTIONAL MELTING

A purification process for substances that are difficult to purify under standard conditions has been developed by the National Bureau of Standards. The process, called "fractional melting" because of its close analogy to fractional distillation, was devised by A. R. Glasgow, Jr., and G. S. Ross of the Bureau's pure substances laboratory to meet the continuing demand for purer materials in scientific research. It has been applied to the purification of 2,5-dichlorostyrene, which is used as a "potting agent" in electronic components.

Conducted in a closed, inert system under equilibrium conditions, the fractional melting procedure is well suited for the purification of substances that are corrosive, hygroscopic, toxic, or reactive in air. It has several advantages over the conventional fractional crystallization. These include easy separation of contaminants and convenient purification of small samples, with a high percentage of yield.

For a maximum pure yield, it is important that the process of crystallization be extremely gradual because this enables the crystal to form without inclusion of surrounding impurities. Slow crystallization also produces larger crystals. These have a smaller ratio of surface area to mass; therefore the total amount of absorbed impurity on the crystalline faces is reduced.

In earlier methods, the separation of the mother liquor from the

(Continued on Page 52)

Book Review—

FUNDAMENTALS OF MECHANICAL DESIGN

by Richard M. Phelan

Reviewed by Eugene S. Ault

Professor Phelan born thirty-seven years ago in Missouri received his BS in mechanical engineering from the University of Missouri in 1943. He got his first teaching experience in the Navy.

In 1947 he came to Cornell as a graduate student and part-time instructor, receiving his MME in 1950. In 1953 he was appointed to his present position as associate professor. He is currently teaching experimental methods of machine design and design problems in vibrations and dynamics.

Any author of a machine design textbook is soon aware that his greatest problem is deciding what topics will be discussed and to what extent these selected topics should be treated. Thus it is imperative that the author have clearly in mind the particular users of his book and try to give the most desirable coverage of the topics.

Professor Phelan clearly states his objectives in his preface. He is aiming at presenting to non-Mechanical Engineers portions of mechanism, dynamics of machinery, and design of machine elements most helpful to them—all for assimilation within a limited time. The author wishes to emphasize problem solution based upon principles rather than upon "number plugging" in formulas from a handbook.

The book opens with a chapter on definitions, followed by a chapter on linkages, wherein are treated varieties of the four-bar linkage and inversions of the slider-crank. Treatment is brief but adequate and well illustrated. Two chapters cover displacement, velocity, and acceleration, again confined to simple applications. The instant center of velocity is mentioned and its use illustrated, after which the velocity polygon is introduced. The instant center concept is valuable in aiding understanding of motions and is better not omitted, as advocated by some. Illustrations are simple, so the student would require some guidance in solving problems of even mild complexity. The chapter on cams is clear and sufficient for its purpose. These above mentioned chapters dispose of the usual material of Mechanism, except for rotary motion transmitters, which are treated, along with strength consideration, in the design section.

I feel that the factor of safety for repeated loads is too complicated for the level of this text and the space could have been more effectively used by a more extensive discussion of the mechanics of fatigue failure. Stress concentration is given good emphasis, although the inclusion of so many charts is questionable.

The chapter on mechanical fasteners includes bolts and keys, which one might expect to be under screw threads and shafting, respectively. Because of this arrangement relationship between setting-up torque and axial load is not evident. Later, in the chapter on power screws, this relationship is fully derived and then simplified to a practically useful equation. In this text it might be justifiable to make simplifying assumptions first in order to save space. Power screws are given relatively more attention than they merit. The author could defend this because he uses this occasion to introduce a good analysis problem. Space saved here could well be devoted to leaf spring calculations which are unexplainably omitted from the chapter on springs. Helical springs are adequately treated. Considerable space is given to illustrations of shaft couplings.

The chapter on intermittent-motion mechanisms includes clutches, whereas brakes are treated separately. The essential difference between a brake and a clutch is only the final speed of the controlled member. The treatment of brakes utilizes the opportunity for force analyses.

Belts and rope drives and chains

ABOUT THE REVIEWER

Professor Eugene S. Ault is Head of the Machine Design Department at Purdue University. An experienced technical writer, he is co-author of the text, "Fundamentals of Machine Design," and numerous articles in engineering journals. He attended Baltimore Polytechnical Institute, Johns Hopkins University and Cornell University. He has instructed machine design at Cornell, Rice, Lehigh and Case. He is a Fellow of A.S.M.E., and member of A.S.E.E., the American Association of University Professors, Sigma Xi, Pi Tau Sigma and Phi Kappa.

are given ample space and treatment.

The kinematics, strength, and durability of spur gear teeth are appropriately and well treated, accompanied by a good illustrative example. The bending stress across a gear tooth is illustrated in Fig. 16-146 as a curved, instead of a straight line, but no comment is made about this anomaly. Bevel, helical, hypoid, and worn gears are not analyzed for strength or durability. Gear trains and variable speed drives are well illustrated and described.

The treatment of journal bearing lubrication is not so satisfying as other portions; it seems mostly the using of charts without an explanation of principles involved. Boundary lubrication is barely mentioned. Some of the space given to the many illustrations of rolling bearings might well have been used for a fuller account of rating practices, or more "practically," illustrations of bearing mountings.

Vibrations are introduced sufficiently to make the reader conscious of their existence.

A series of tables giving data for problem solution is provided. Problems are well selected and graded and are all placed at the end of the book.

The author has realized his aims satisfactorily and has presented a text very well suited for brief, selective treatment of a subject of wide range. We are planning to use this text at Purdue for a non-Mechanical course.

CRYOGENICS

(Continued from Page 26)

shell can be produced through vapor plating. Other ways of decreasing the time constant are reducing the gate wire diameter (L/R decreases as the fourth power of the diameter) but at a sacrifice of current gain, and alloying to increase the normal state resistivity of the superconductive wire.

The fabrication problems of cryotrons will probably be solved as soon as more experience is gained in dealing with these new devices.

Without a doubt cryotrons have a bright and glorious future ahead. Their small size, low power requirements, high reliability, high speed of operation it is hoped, and easy fabrication, put them in the same position today that the vacuum tube was fifty years ago. Moreover, with the doors to space travel being opened even at this present moment, the operation of cryotrons in the near absolute zero temperatures of outer space can be regarded as a sure thing for the future.

TECHNIBRIEFS

(Continued from Page 50)

pure crystals was difficult and ineffective. With the present equipment, however, the tube can be inverted, permitting the concentrated impurity content, which is retained in the crystals growing near the top, to be melted and retrieved first. This avoids unnecessary contamination of the pure substance and allows a larger percentage yield of highly purified material—approximately 99.95 per cent pure.

COLLEGE NEWS

(Continued from Page 41)

battled against bitter opposition for the city to acquire the filtration plant of the old Ithaca Water Works.

Professor Mason, recipient of the new professorship, received the Ph.D. from Cornell University in 1924. He was born in Watertown, South Dakota, and received the B.A. degree from the University of Oregon in 1919. He is the author of "Introductory Physical Metallurgy" and of over forty papers on various applications of microscopy.

During and after World War II, Professor Mason was technical representative of the National Defense Research Committee, directing projects for the Army Chemical Corps at Cornell.

Professor Mason has served as chairman of the division of microchemistry of the American Chemical Society and has been consultant to various industries. He is a member of the American Chemical Society, American Society for Metals, American Institute of Mining, Metallurgical and Petroleum Engineers, American Society for Testing Materials, British Institute of Metals, Sigma Xi, Phi Kappa Phi, Tau Beta Pi and Alpha Chi Sigma.

He is at present on sabbatical leave from the University and is engaged in rewriting Volume I of the "Handbook of Chemical Microscopy" to be published in September.

Why Vought Projects Bring Out The Best In An Engineer

At Vought, the engineer doesn't often forget past assignments. Like all big events, they leave vivid memories. And it's no wonder.

For here the engineer contributes to history-making projects — among them the record-breaking Crusader fighter; the Regulus II missile, chosen to arm our newest nuclear subs; and the new fast-developing 1,500-plus-mph fighter, details of which are still classified.

The Vought engineer watches such weapons take shape. He supervises critical tests, and he introduces the weapons to the men with whom they will serve.

Engineers with many specialties share these experiences. Today, for example, Vought is at work on important projects involving:

electronics design and manufacture

inertial navigation

investigation of advanced propulsion methods

Mach 5 configurations

Vought's excellent R&D facilities help the engineer through unexplored areas. And by teaming up with other specialists against mutual challenges, the Vought engineer learns new fields while advancing in his own.

★★★

Would you like to know what men with *your* training are doing at Vought . . . what *you* can expect of a Vought career?

For full information, see our representative during his next campus visit.

★★★

Or write directly to:

C. A. Besio
Supervisor, Engineering Personnel
Dept. CM- 6

CHANCE VOUGHT AIRCRAFT
INCORPORATED DALLAS, TEXAS

A Vought Vignette
ONE OF A SERIES

The development engineer who exercised his option

When it comes to end products, Bill Crowder never finishes what he starts.

While Bill's colleagues were bringing to completion a missile that he initiated, Bill helped launch eight other major projects and some minor studies. A restless record. But that's his privilege in Chance Vought's Development Section.

Bill's department analyzes requirements for new weapons. Specs come from the military, or from Vought's own Advanced Development Planning Group. They outline an approaching void or shortcoming in our defense structure. It's up to Bill and from three to thirty project teammates to produce an idea that will fill the vacancy.

From Development's desks and bull sessions come new configurations. Some are radically different; others, close to conventional. The best are projected, electronically, into the environments they must dominate.

For example, Bill can forecast a proposed missile's flight behavior by studying analog traces and columns of IBM tabulations. Electronically, he can observe minute performance details such as gust effects on a recoverable missile's landing approach.

Tests like these refine from Bill's own offerings and those of others the configuration that best answers the problem. Once this pattern is "ballparked" for approximate actual size, it's ready for detail design . . . likely to become a full-scale project.

Time now for Bill to exercise an option all Vought development engineers enjoy. He may follow the project he's begun the full route to completion. Or he may remain in Development and accept a new assignment.

To himself, Bill justifies his choice something like this: "Changing assignments gives me a chance to shift gears . . . to change my approach . . . to broaden myself."

To project engineers, anxious for him to follow a promising project out of Development, Bill's "no thank you" is practically a matter of course.

They know he's already cleared his desk for the next new challenge.

At Chance Vought the Development Engineer explores a unique variety of configurations and operational environments. He may limit his analyses of land- and sea-based weapons to preliminary design studies, or he may accompany his project through the complete development cycle.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

Henri Bergson...on making gods

Humanity is groaning, half-crushed under the weight of the progress it has made. Men do not sufficiently realize that their future depends on themselves. They must first decide whether they wish to continue to live. They must then ask whether they want merely to live, or to make the further effort necessary to fulfill, even on our unmanageable planet, the essential function of the universe, which is a machine for making gods.

Les deux sources de la morale et de la religion, 1932

THE RAND CORPORATION, SANTA MONICA, CALIFORNIA
A nonprofit organization engaged in research on problems related to national security and the public interest

Pump-turbine design is now the work . . . hydraulics, the field . . . of John Jandovitz, BSME graduate of College of City of New York, '52.

Water conditioning chemical, service, and equipment specialist in Houston is new assignment of Arthur Brunn, BS Chem. E., University of Tennessee, '56.

Field sales engineering of America's widest range of industrial products is choice of Roy Goodwill, BSME, Michigan State College, '54.

Recent Training Course Graduates

select wide choice of careers at Allis-Chalmers

Starting up a cement plant in Mexico after coordinating all work on it is latest job of John Gibson, BS Met. E., University of California, '54.

Nucleonics is chosen field of R. A. Hartfield, BME, Rensselaer Polytechnic Institute, '53. Currently he is working on design and development of new nuclear power plant.

THERE'S variety at Allis-Chalmers. Whether you're thinking in terms of types of industries, kinds of equipment, types of jobs, or fields of work, the diversification of Allis-Chalmers provides unsurpassed variety. For example:

Types of jobs	Industries	Equipment	Fields
Research	Agriculture	Tractors	Metallurgy
Design	Cement	Kilns	Process Engineering
Manufacturing	Chemical	Screens	Mechanical Design
Application	Construction	Earth Movers	High Voltage Phenomenon
Sales	Electric Power	Transformers	Stress Analysis
	Mining	Crushers	Nucleonics
	Nuclear Power	Reactors	Electronics
	Paper	Control	Hydraulics
	Petroleum	Pumps	Acoustics
		Motors	Thermodynamics
		Steam Turbines	

An outstanding training program, started in 1904, is designed to help you find the activity within these groupings for which you are best suited. Up to two years of theoretical and practical training are offered. Direct employment at Allis-Chalmers is available for those with sufficient background.

Learn more about Allis-Chalmers and its training program. Ask the A-C district office manager in your area or write Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

STRESS *and* STRAIN...

"And now, can anyone tell me where God lives?" asked the Sunday school teacher.

"I know," replied Bobby eagerly. "He lives in our bathroom."

"Why do you say that?"

"Because every morning my father stands at the bathroom door and yells, "God! Are you still in there!"

• • •

Social Worker: "Sir, would you be interested in contributing something to the old ladies home?"

Spendthrift: "Sure, I'll send my mother-in-law over tomorrow."

• • •

A man will soon be able to get clear around the world in two hours: one hour for flying, and the other to get out to the airport.

• • •

With the successful launching of a satellite with a dog inside, Russian scientists are planning a second animal launching. Soviet geneticists are busy trying to develop a breed of cattle small enough to fit into a sputnik. This will be the herd shot 'round the world.

• • •

And then there's the Ch.E. who offered his girl a scotch and sofa and she reclined.

• • •

If it's funny enough to tell, it's been told; if it hasn't been told it's too clean; and if it's dirty enough to interest an engineer the editor gets kicked out of school.

• • •

EE: "Lady, I've found the trouble with your car. You've got a short circuit in the wiring."

Lady: "Well, for goodness sake, lengthen it!"

• • •

Mother: "Daughter, didn't I tell you not to let strange men come to your apartment. You know how it makes me worry."

Daughter: "It's all right, Mother, I went to his apartment, now let his mother worry."

A professor, who long suspected his class was drowsing off on him, decided to catch everyone off base. During the lecture he suddenly dropped into doubletalk.

"You then take the loose sections of fendered smolg and gwelg them —being careful not to overheat the broughtabs. Then extract and wapf them gently for about a time and a half. Fwengle them each twice, then swiftly dip them in blinges, if handy. Otherwise discriminate the entire instrument in twetchels. Are there any questions?"

"Yes," came a sleepy voice from the rear. "What are twetchels?"

• • •

Some females think that low-cut evening gowns are indecent. Others are stacked.

• • •

The Engineer's Psalm

Professor Smith is my instructor; I shall not pass.

He maketh me to exhibit mine ignorance before the whole class.

He telleth me more than I can write,

He lowereth my grade.

Yea, though I walk through the corridors of knowledge, I do not learn.

He tries to teach me;

He writeth the equations before me in hopes that I will understand them.

He bombardeth my head with integrations, My sliderule freezeth up,

Surely enthalpies and entropies shall follow me all the days of my life,

And I shall dwell in the College of Engineering forever.

—Unanimous

• • •

It isn't what my girl knows that bothers me, it's how she learned it.

• • •

Late to bed
And early to rise
Keeps your roommate
From wearing your ties.

Professor: "This exam will be conducted on the honor system. Please sit three seats apart and in alternate rows."

• • •

"When I was your age, young lady," her mother said sternly, "a nice girl didn't think of holding a man's hand."

"But Mother," the daughter protested, "nowadays a nice girl *has* to hold a man's hand."

• • •

An inmate of the lunatic asylum was to be examined for dismissal. The first question he was asked was: "What are you going to do when you get out of here?"

The inmate replied: "I'm going to get me a slingshot and come back and break every window in this place."

After another six months in the padded cell, he was again examined and the same question was put to him.

"Well, I'm going to get a job," was the reply.

"Fine," said the examiner, "And then what?"

"Then I'm going to buy a big car."

"Good."

"And then I'm going to meet a beautiful blonde."

"Then I'm going to take her out driving on a lonely road."

"Yes."

"Then I'm going to grab her garter, make a slingshot, and come back here and break every window in this place."

• • •

During mock maneuvers an army commander ordered a notice to be displayed on a bridge stating: "This bridge has been destroyed by air attack." But to his chagrin, he noticed through his field glasses that a foot regiment was crossing the bridge despite his orders. He sent his adjutant to the officer in charge post-haste to find out how he dared to defy his orders. An hour later the adjutant was back. "It's all right, sir," he reported. "The troops are wearing signs saying 'We are swimming'."

1,000 styles—750 stores—yet photography gives headquarters inventory figures overnight

Thom McAn ends ten-day hand-copying jobs with Kodak's Verifax Copier—now gets complicated sales, size and style data off in a day.

BEFORE, when Thom McAn's merchandise manager or stylist needed word on sales or style trends in certain stores, it took as much as ten days to hand-copy the records.

But today, when headquarters located in New York requests information on any shoe style or store, the New England merchandising center gets the latest facts and figures away in that night's mail. And styling, buying and distributing functions get 24-hour—instead of ten-day—service on vital stock allotment statistics.

This is because the facts, kept on files of removable panels and cards, can be slipped into a Kodak Verifax Copier and copied, photographically accurate, in a minute.

Photocopying is just one of hundreds of ways photography works today for all kinds of businesses, large and small. It helps with product design, takes kinks out of production, increases sales, improves customer and personnel relations.

Thom McAn calls the Verifax Copier "the kingpin of the allotment control system." It copies a store's style allotment records and width breakdowns and in less than 60 seconds has a dry print ready for the mails.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production. If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Kodak
TRADE MARK

One of a series*

Interview with General Electric's Earl G. Abbott Manager—Sales Training

Advancement in a Large Company: How it Works

Where do you find better advancement opportunities—in a large company or a small one? To help you, the college student, resolve that problem, Mr. Abbott answers the following questions concerning advancement opportunities in engineering, manufacturing and technical marketing at General Electric.

Q. In a large Company such as General Electric, how can you assure that every man deserving of recognition will get it? Don't some capable people become lost?

A. No, they don't. And it's because of the way G.E. has been organized. By decentralizing into more than a hundred smaller operating departments, we've been able to pinpoint both authority and responsibility. Our products are engineered, manufactured and marketed by many departments comparable to small companies. Since each is completely responsible for its success and profitability, each individual within the department has a defined share of that responsibility. Therefore, outstanding performance is readily recognized.

Q. If that's the case, are opportunities for advancement limited to openings within the department?

A. Not at all. That's one of the advantages of our decentralized organization. It creates small operations that individuals can "get their arms around", and still reserves and enhances the inherent advantages of a large company. Widely diverse opportunities and promotions are available on a Company-wide basis.

Q. But how does a department find the best man, Company-wide?

A. We've developed personnel registers to assure that the best qualified men for the job are not overlooked. The registers contain complete appraisals of professional employees. They enable a manager to make a thorough and objective search of the entire General Electric Company and come up with the man best qualified for the job.

Q. How do advancement opportunities for technical graduates stack-up with those of other graduates?

A. Very well. General Electric is recognized as a Company with outstanding technical skills and facilities. One out of every thirteen employees is a scientist or engineer. And approximately 50 per cent of our Department General Managers have technical backgrounds.

Q. How about speed of advancement? Is G.E. a "young man's Company"?

A. Definitely. A majority of all supervisors, managers and outstanding individual contributors working in the engineering function are below the age of forty. We believe that a job should be one for which you are qualified, but above all it should be one that challenges your ability. As you master one job we feel that consideration should be given to moving you to a position of greater responsibility. This is working, for in the professional field, one out of four of our people are in positions of greater responsibility today than they were a year ago.

Q. Some men want to remain in a specialized technical job rather than go into managerial work. How does this affect their advancement?

A. At G.E. there are many paths which lead to higher positions of recognition and prestige. Every man is essentially free to select the course which best fits both his abilities and interests. Furthermore, he may modify that course if his interests change as his career progresses. Along any of these paths he may advance within the Company to very high levels of recognition and salary.

Q. What aids to advancement does General Electric provide?

A. We believe that it's just sound business policy to provide a stimulating climate for personal development. As the individual develops, through his own efforts, the Company benefits from his contributions. General Electric has done much to provide the right kind of opportunity for its employees. Outstanding college graduates are given graduate study aid through the G-E Honors Program and Tuition Refund Program. Technical graduates entering the Engineering, Manufacturing, or Technical Marketing Programs start with on-the-job training and related study as preparation for more responsible positions. Throughout their G-E careers they receive frequent appraisals as a guide for self development. Company-conducted courses are offered again at all levels of the organization. These help professionals gain the increasingly higher levels of education demanded by the complexities of modern business. Our goal is to see every man advance to the full limits of his capabilities.

If you have other questions or want information on our programs for technical graduates, write to E. G. Abbott, Section 959-9, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: • Qualities We Look For in Young Engineers • Personal Development • Salary.**

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